Director, Operational Test and Evaluation

FY 2020 Annual Report

January 2021

This report satisfies the provisions of Title 10, United States Code, Section 139. The report summarizes the operational test and evaluation activities (including live fire testing activities) of the Department of Defense during the preceding fiscal year.

Robert F. Behler
Director

FY 2020 Annual Report

The United States military continues to be the strongest and most talented force on the planet. Our women and men in uniform – all volunteers – remain committed to the Constitution, preserving American freedom and prosperity, and supporting our allies. Their success in this most fundamental mission reflects their intelligence, bravery, and dedication to their fellow Americans. It also reflects the capabilities we place in their hands.

The operational and live-fire test and evaluation communities hold a most solemn responsibility: independently assessing those capabilities for effectiveness, suitability, survivability, and lethality in near-real-world combat conditions. Our evaluations determine whether a production-representative system does what it's supposed to, whether the warfighter can use it safely, and whether the warfighter can depend on it in combat.

DoD's operational and live-fire T&E have been sufficient to provide accurate information to decision makers in the department and on Capitol Hill, and to users – American warfighters, our national treasure. As global threats grow, however, with near-peer adversaries closing the capability gap, and the number and severity of potential attack vectors rapidly expanding, the very fundamentals of operational and live-fire T&E must be examined: Does the Defense Department have the right tools, infrastructure, processes, and people to properly evaluate the extraordinary technologies we plan to field next year and more than 10 years from now? Are we testing the right aspects of our systems and putting enough focus on the types of realistic threats and vulnerabilities our adversaries are likeliest to exploit? Is T&E prepared to adapt to global conditions in real time? How can testing streamline the acquisition process?

DOT&E is delving into these issues and, it appears, the time for significant change has arrived. As good as operational and live-fire test and evaluation are today, we must make them better – more effective, more efficient, more robust, and more flexible. We also must create a holistic set of capabilities and infrastructure to ensure that our newest branch, Space Force, can benefit from the same independent, rigorous assessments as its sister Services. Bringing T&E into the 21st century will require substantial investment, a different approach to acquiring expertise, and intragovernmental support of the live-fire and OT&E mission. That commitment of resources, time, and energy will pay enormous dividends for our women and men in uniform.

FY20 HIGHLIGHTS

Integrating Developmental and Operational Test & Evaluation

We are now 20 years into the 21st century but, in many ways, DoD acquisition functions appear to be stuck in the 20th century. Our processes are too slow. By the time many of our systems roll off the production line, the requirements against which they were designed are decades-old and no longer capture the threat or warfighter needs. With our near-peer adversaries rapidly gaining ground, and even getting ahead of us in certain areas, continuing along this path is dangerous!

To help make development and fielding more dynamic, in 2020 DOT&E and the developmental test (DT) community took the first steps to integrating DT and OT. DoD traditionally has executed test and evaluation in a segmented, sequential fashion. The strict DT-OT bifurcation is delaying getting weapons into the hands of the warfighter.

Test activities in key DoD programs, including the B-21, the VH-92A, the CH-53K, the MK-48 heavyweight and MK-54 lightweight torpedoes, submarine sonar systems, and many net-centric systems, are showing that the siloed, linear approach can be set aside – and that, by doing so, DoD can cut the time to field major weapon systems by as much as 40 percent. Developmental system configurations and conditions can yield OT-quality data for certain measures of effectiveness, suitability, and performance. Conducting incremental cyber assessments of each developmental system configuration, using the OT perspective, creates a cumulative body of evidence that enables more tailored and focused cybersecurity test events during initial OT&E (IOT&E).

A handful of guiding principles has emerged from these forays into DT-OT integration. Early DT-OT collaboration to shape DT plans is essential in order to maximize the opportunity for OT data collection during "dual-use" DT events. Similarly, the program must have a DOT&E-approved "early OT" concept prior to entering the engineering and manufacturing development phase. A collaborative, integrated-testing, data-scoring board, with program office, DT, and OT representatives, will approve each specific use of developmental and integrated test data for early OT reporting.

These process changes will not affect DOT&E's position as the sole independent source of authoritative OT&E data and findings. Dedicated IOT&E will still be necessary; not every OT requirement can be satisfied by early integrated test events. But, by gathering OT-type data and reporting it as soon as we know it, we can make testing more efficient and effective, and support better decision making.

F-35 and the Joint Simulation Environment

In FY20, F-35 testing crossed a major milestone, finishing planned open-air combat and electronic attack trials. Two IOT&E weapons test trials were scheduled for October 2020 and early calendar year 2021; a third weapons test included in the original test plan has been deferred to a later program phase.

A substantial amount of testing remains, and it cannot be executed until the Joint Simulation Environment (JSE) is ready. The JSE is a man-in-the-loop, software-in-the-loop mission simulator that will provide the only venue, other than actual combat, to test the F-35 against modern threats in realistic densities and mission scenarios. Development of the JSE is now more than three years behind schedule. In late fall 2020, the Joint Program Office projected that completion of the 64 mission trials planned for the JSE would slip to mid or late calendar year 2021.

The data to be gathered via the JSE are essential to test adequacy. DOT&E cannot write the statutorily required beyond low-rate initial production report until the 64 JSE trials have been completed and the data analyzed.

Once the JSE is fully functional and IOT&E finished, the JPO will need to focus on ensuring that it remains verified, validated, and accredited (VV&A) for the rapid software cycle planned for future blocks of the F-35. The continuous capability development and delivery model will produce a new software release every six months. As currently constructed, test plans do not appear to collect enough open-air flight data to conduct sufficient VV&A for Block 4 capabilities.

Longer term, DoD must explore maximizing our investment in JSE by adding other current and future air platforms, and by expanding its simulations to cover space and cyberspace. As with the F-35, DoD largely cannot test space assets or weapons system cybersecurity live or in operationally representative conditions. JSE's high-fidelity environment potentially could provide a venue to assess these critical operational capabilities against realistic threats.

PREPARING LIVE-FIRE AND OPERATIONAL TEST & EVALUATION FOR THE NEXT DECADE AND BEYOND

The next 10 years may prove to be the most challenging period in the history of live-fire and operational test and evaluation. The capabilities of near-peer competitors are advancing at breakneck speed. Many systems in our acquisition pipeline comprise technology never before fielded. The creation of Space Force brings to the forefront an increasingly crowded and contested domain. And the potential for harm, and even mission failure, as a result of cybersecurity failures continues to grow.

Are DoD Ranges Ready for the Future?

At the end of FY20, DOT&E engaged the National Academies of Sciences, Engineering, and Medicine (NASEM) to conduct an independent, objective, peer-reviewed study of the DoD test and training ranges used for live-fire and operational test and evaluation. The two-part study will assess the adequacy of ranges and associated infrastructure in the 2025-2035 timeframe to support DOT&E's statutory mission to establish a system's operational effectiveness, suitability, survivability, and lethality.

The first tranche of the study will examine test and training ranges' physical suitability, to include capacity / throughput, condition of infrastructure, security, and encroachment challenges; and their technical suitability, which includes instrumentation, cyber and analytic tools / algorithms, and modeling and simulation capabilities. NASEM will release an unclassified report on these areas to the public in summer or early fall 2021.

Concurrently, a second NASEM team will examine ranges' operational suitability. This includes threat and threat countermeasure replication and representation, which are crucial to both testing and training; capacity for advanced weapons; spectrum management; and infrastructure cybersecurity. The assessment of advanced weapons and threats will cover, but not necessarily be limited to, directed-energy weapons, hypersonic systems, 6th generation aircraft, autonomous systems, artificial intelligence, space systems and threats, and advanced active electronic warfare / cyber capabilities. The final report will be classified but available to DoD and the Congress.

Both reports will present conclusions regarding whether DoD test and training ranges can fulfill our anticipated needs. Importantly, each will also offer actionable recommendations.

The T&E Resources section of this report already notes multiple existing shortfalls. And, after three years of visiting our ranges and test facilities, I can offer this admittedly unscientific observation: The majority of our ranges were built around World War II (planes still fly over the same terrain at Eglin Air Force Base that the Doolittle Raiders used to train for their famous 1942 Japan raids); most were updated at the height of the Cold War in the 1980s; but little has been done since then. I anticipate that NASEM will independently determine the same and I strongly encourage DoD planners and programmers, as well as Capitol Hill, to start thinking now about how to make capabilities and infrastructure match our warfighters' and testers' needs.

Space Test & Training

Since last year's report, Space Force has made great strides in standing up our newest cadre of warfighters. In November 2020, Gen. John Raymond, Space Force commanding general, assigned Space Training and Readiness Command (STARCOM) responsibility for operational test and evaluation. DOT&E looks forward to collaborating with STARCOM as it grows and begins to crystallize OT&E and training processes and plans.

The creation of STARCOM comes at a pivotal moment. The likelihood that the next fight will occur in space and cyberspace before it goes kinetic is high. And, over the Future Years Defense Plan, DoD intends to spend nearly $100 Billion on space assets. Yet, the department has no operationally realistic way of testing space-based systems. Currently, DoD expects to spend less than 1 percent of space program acquisition funding on test infrastructure. DoD would be wise to invest significantly more than that to develop a National Space Test and Training Range (NSTTR).

To be operationally representative, the NSTTR threat array must include cyber, directed-energy, kinetic, and electronic-warfare threats, as well as natural hazards. This multi-layered capability would be multifunctional, as well, supporting development and validation of space-based warfighting tactics, techniques, and procedures, development of multi-domain operating concepts, and more effective warfighter training.

Space systems present a significant challenge. They form our data, command and control, intelligence, surveillance, and reconnaissance highways, and they constitute an unprecedented attack surface. Each component of the space system architecture is vulnerable to cyber threats: the orbital segment (the spacecraft itself), the terrestrial segment (ground equipment required to operate the spacecraft), and the link segment (which transmits data between and among the orbital and terrestrial segments using electromagnetic spectrum). All three of these elements must be demonstrably cyber-secure, and the testing community must have the right talent and tools to assess them properly.

Cybersecurity

Space-based platforms' need for stringent cybersecurity is emblematic of DoD as a whole. Nearly every warfighting and business capability is now software-defined. Simply put, the system – plane, ship, vehicle, radio, operations center, missile, satellite, health records management – doesn't work if the software doesn't work. We are likelier to upgrade a system by installing new software than by replacing hardware. Yet, cybersecurity often is treated as an add-on feature, rather than being "baked in"; and our ability to assess and protect software, though improving, is not keeping pace with our reliance on it or our adversaries' ability to compromise it. In FY20, 62 percent of test plans noted cybersecurity testing limitations. Over the last several years, cybersecurity flaws have been the most common reason DOT&E determined a system to be not completely survivable.

Every program manager and every tester must be able to answer the same basic questions: How good is our software, and how do we know? How do we know our systems are secure? How do we know when we are being hacked, or when something anomalous has occurred in our software? How do we test to ensure that we minimize the maximum regret? And, with deference to the taxpayer, how much will the software cost over its lifetime, including updates and continuous testing of those updates?

Some aspects of cybersecurity OT&E are improving. Operational test agencies have broadened and made more rigorous the testing of systems that rely on Internet Protocol. More organizations are requesting assistance from DOT&E's Cybersecurity Assessment Program, which focuses on defense against advanced threats. And, the T&E community is strengthening cybersecurity testing processes; new guidance should be released in FY21.

Significant cybersecurity T&E gaps remain, however. Tools and techniques necessary to test specialized protocols, such as those in industrial control systems, tactical data links, and aircraft transponders, are not adequate. DOT&E is growing capabilities to execute threat-realistic cyber assessments against these technologies. In addition, DoD must ramp up realistic T&E of offensive cyberspace operations capabilities and procedures to give commanders confidence in their availability and efficacy. Test and evaluation of the junction between cyber and electromagnetic spectrum operations, and the burgeoning threat vector of cloud-based computing, must be augmented, as well.

More fundamental, though, is DoD systems' inability to self-monitor continuously for anomalies: The user doesn't know the health of her system's software. The plethora of gauges in today's cockpits tells the pilot almost everything she needs to know regarding the status of her aircraft. The one parameter into which she has no insight is the plane's software – and she likely won't know until something catastrophic occurs.

With software driving nearly everything we place in the warfighter's hands, this information shortfall is no longer tenable. Red-teaming and cybersecurity vulnerability penetration assessments are good but the software "surface" is too large and the pace of operations too fast for humans to keep up. The warfighter needs a 24/7, automated, autonomous software monitoring and testing capability that alerts her to defects, malware, hacking, and other types of compromise and failure.

People Are the Key

With its dependence on software, the department faces a breathtaking human-capital requirement. Development of cutting-edge cybersecurity testing tools and processes, and preventative diagnostics; in-depth understanding of emerging adversary techniques and capabilities; and the innovation necessary to adopt, test, and manage systems fueled by artificial intelligence and machine-learning demand a skillset that does not exist in DoD today. And, the department cannot build it internally: DoD will always be outbid in salary and geographic and workplace flexibility by the private sector. We therefore must apply a different model to get the people we need in the information technology, software, and cybersecurity spheres.

To tap the necessary creativity, intellect, and deep domain expertise, DoD should establish a federated university-affiliated research center (UARC). Similar to the university consortium for applied hypersonics that the Deputy Undersecretary of Defense (Research and Engineering) launched in October, a cyber UARC would give DoD access to the top tier of academia and their supporting partners in the commercial world. Instead of a full-time, static, in-house workforce, DoD would reach into the UARC as needed. This talent pool, which already is breaking boundaries in software, IT, and cybersecurity, is the only means to keeping DoD and our warfighters ahead of our adversaries.

COVID-19: IMPACTS AND OPPORTUNITIES

Live-fire and operational T&E are critical elements of DoD's acquisition process. The T&E community does whatever it takes to ensure that the equipment the department intends to field has been thoroughly assessed and its performance is understood. COVID-19, however, made this year as challenging for testers as it was for the rest of the country.

To protect the health of our personnel and their families, DOT&E followed national guidelines and significantly restricted travel from the middle of March through the end of the fiscal year. Action officers participated only in events deemed mission-essential by the Services, such as CVN 78, CH-53K, F-35, KC-46, and Amphibious Combat Vehicle testing. DOT&E's primary federally funded research and development center, the Institute for Defense Analyses (IDA), similarly limited travel to tests, as well as other office-based support, in order to safeguard its employees.

These constraints, and changes the Services and agencies instituted in response to the pandemic, affected T&E for one-third of programs under oversight. Certain tests and associated activities were postponed; others went forward with a reduced scope or number of events. In some cases, the DOT&E action officer and/or IDA analysts could not attend a test or preparatory event in person. Just over 20 percent of events scheduled for support from the Center for Countermeasures slid from the third to the fourth quarter of FY20, another 20 percent were postponed until FY21, and two were canceled.

The number of DOT&E cyber events and assessments for efforts not under oversight also was substantially smaller due to cancellations and postponements by sponsors. The notable exception was DOT&E's persistent cyber operations team, which logged its highest demand and operating tempo ever, driven particularly by combatant command requests to help facilitate operations by off-site personnel.

A chart highlighting which programs were impacted can be found on page 9, and details of COVID-related changes are included in individual program articles.

The unexpected and sudden halt to normal business revealed a substantial gap in DoD's T&E capabilities. While sectors of the commercial world were able to quickly resume their production monitoring and acceptance testing via telepresence technologies, the Services, agencies, and DOT&E largely were not prepared to adapt to COVID reality. Without question, the live-fire and operational T&E communities need that flexibility. Even in the face of a global pandemic, national defense cannot stop, and that includes the test and evaluation on which our decision makers and warfighters rely.

With that in mind, last summer DOT&E began to explore the feasibility of remote participation in live-fire and operational T&E. Given the wide variety of systems under oversight, the worldwide distribution of test events, and the classification of the information they generate, we envision a remote presence suite that includes: a high-capacity, reliable, and very secure transport layer; extremely high-definition, real-time video, often of multiple locations; two-way, live audio; possibly capabilities that replicate other human senses; and multiple collaboration tools.

Many of these technologies already exist and now is the time to determine how well they work in the live-fire and operational T&E context. The first logical target for a remote / telepresence operational test is an IT system. Much of the OT data for IT systems already is collected remotely. Where beneficial, live screen and data sharing, and real-time video and audio that allow the evaluator to observe users in action and to speak to them, potentially would be enough to complete the toolkit. Live-fire testing of major platforms, such as tanks, also is an immediate candidate for remote presence. Again, secure live video and audio would be required. In addition, a small, remote-controlled device that crawls over, under, and inside to examine damage, perhaps paired with a virtual or augmented reality system, potentially could be used to replicate the in-person experience.

It's safe to say that remote T&E won't be possible for every type of event or every type of system, but we must launch proofs of concept now to start building this critical capability. While the end of the COVID pandemic may be in sight, DoD cannot forego this opportunity to prepare for the next existential crisis; continuity-of-operations capacity must be at the top of the department's objectives. And there will be a bonus: Remote presence will improve general efficiency and efficacy, as well.

Remote T&E will require potentially large technology and infrastructure investments across the entire department. Protecting the integrity of live-fire and operational T&E, the health of our personnel, and national security will be money well-spent.

THE ROAD AHEAD

Serving my country and my sisters and brothers in arms as the Director, Operational Test & Evaluation has been a tremendous honor, and one I did not take lightly. Warfighters rely on the test community to stand as unbiased, independent arbiters of system quality and performance. Our work allows them to adhere to the third imperative of combat: Believe in your equipment and weapons.

The women and men of DOT&E have fulfilled this duty exceptionally well over my three years in office. For their success to continue, as the volume of ever-more complex systems in the acquisition pipeline grows, the department must provide live-fire and operational T&E resources that match the mission. DOT&E will continue to explore ways to augment efficacy and efficiency. With the right support from our partners throughout the Defense Department and in Congress, DoD's live-fire and operational test and evaluation communities will keep America safe and strong.

Robert F. Behler
Director

Contents

DOT&E Activity and Oversight

DOD Programs

Army Programs

Navy Programs

Air Force Programs

FY20 TABLE OF CONTENTS

DOT&E Activity and Oversight

DOT&E Activity and Oversight

FY20 Activity Summary

DOT&E activity for FY20 involved oversight of 228 programs, including 14 Major Automated Information Systems (MAIS). Oversight activity begins with the early acquisition milestones, continues through approval for full-rate production, and, in some instances, during full production until removed from the DOT&E oversight list.

Our review of test planning activities for FY20 included approval of 26 Test and Evaluation Master Plans (TEMPs), 1 Test and Evaluation Strategy, 52 Operational Test Plans, and 4 LFT&E Strategies/Management Plans (not included in a TEMP). DOT&E also disapproved the proposed LFT&E Alternate Plan for the Guided Missile Frigate (FFG(X)). After changes were made, the plan was subsequently approved.

In FY20, DOT&E prepared 20 reports for Congress and SECDEF: 1 Cybersecurity report, 3 Early Fielding reports, 4 FOT&E reports, 5 IOT&E reports, 1 Operational Assessment (OA) report, 5 special reports, and the Ballistic Missile Defense System Annual Report. Additionally, DOT&E prepared 17 non-Congressional reports for DOD stakeholders: 3 Cybersecurity reports, 1 Early Fielding report, 1 FOT&E report, 1 Limited User Test (LUT) report, 1 Multi-Service OT&E report, 8 OA reports, 1 OT&E report, and 1 Quick Reaction Assessment report. Some of these non-Congressional reports were submitted to Defense Acquisition Board (DAB) principals for consideration in DAB deliberations.

During FY20, DOT&E met with Service operational test agencies, program officials, private sector organizations, and academia; monitored test activities; and provided information to Congress, SECDEF, the Deputy Secretary of Defense, Service Secretaries, USD(R&E), USD(A&S), DAB principals, and the DAB committees. DOT&E evaluations are informed in large part through active on-site participation in, and observation of, tests and test-related activities. In FY20, DOT&E's experts joined test-related activities on 129 local trips within the National Capital Region and 456 temporary duty assignment trips in support of the DOT&E mission.

Security considerations preclude identifying classified programs in this report. The objective, however, is to ensure operational effectiveness and suitability do not suffer due to extraordinary security constraints imposed on those programs.

TEST AND EVALUATION MASTER PLANS/STRATEGIES APPROVED (LF STRATEGIES MARKED WITH *)

AIM-9X - Air-to-Air Missile Upgrade Block II TEMP*

Armored Multi-Purpose Vehicle (AMPV) Change 1 TEMP*

B-52 Commercial Engine Replacement Program (CERP) TEMP

Bradley Engineering Change Proposal (ECP) 2 TEMP

Cannon Delivered Area Effects Munitions (C-DAEM) Armor Increment 1 Projectile Milestone A TEMP*

Carrier Based Unmanned Aerial System MQ-25 TEMP

CMV-22B TEMP*

Combat Rescue Helicopter (CRH) Milestone C TEMP*

Command Post Computing Environment (CPCE) Post IOT&E TEMP Update

Extended Range (ER) Guided Multiple Launch Rocket System (GMLRS) TEMP, Annex E*

F-35 Block 4 TEMP and Annexes*

Guided Missile Frigate FFG(X) TEMP*

Handheld, Manpack, and Small Form Fit (HMS) Leader Radio (LR) TEMP

Heavy Dump Truck (HDT) TEMP*

Javelin Antitank Weapon System TEMP

Joint Air-to-Ground Missile System (JAGM) TEMP

Joint Assault Bridge (JAB) TEMP Addendum

Key Management Infrastructure (KMI) Increment 3 TEMP

Manpack (MP) Radio Generation (GEN) 2 TEMP

MK 54 Mod 1 Lightweight Torpedo (LWT) (Increment 1) TEMP

Patriot System TEMP*

Protected Anti-jam Tactical Satellite System (PATS) Phase 1 Test and Evaluation Strategy

RQ-7Bv2 Block III Shadow Tactical Unmanned Aircraft System (TUAS) TEMP

Stryker Anti-Tank Guided Missile (ATGM) Engineering Change Proposal (ECP) TEMP Annex

T-AO 205 Fleet Replenishment Oiler Program TEMP

XM1158 Advanced Armor Piercing (ADVAP) TEMP*

OPERATIONAL TEST PLANS APPROVED

AC-130J Block 30 Configuration Phase One of the Force Development Evaluation Test Plan

Advanced Multi-Purpose (AMP) Cartridge, 120 mm; High Explosive Multi-Purpose with Tracer (HEMP-T), XM1147; Ammunition Vulnerability Test (AVT) Test Design Plan

Advanced Multi-Purpose (AMP) Limited User Test (LUT) Operational Test Plan (OTP)

Advanced Multi-Purpose (AMP) Hard Target Detailed Test Plan

Advanced Multi-Purpose (AMP) Ammunition Vulnerability Test Plan

Aegis Weapon System Baseline 5.4 Phase 1 Operational Test Plan

Aerosol and Vapor Chemical Agent Detector (AVCAD) Cooperative Vulnerability and Penetration Assessment (CVPA) Test Plan

Aerosol and Vapor Chemical Agent Detector (AVCAD) Engineering Manufacturing Development Chemical Chamber Test Plan

Amphibious Assault Ship Replacement (LHA(R)) Flight 1 Operational Assessment Test Plan

Amphibious Combat Vehicle (ACV) Cooperative Vulnerability and Penetration Assessment (CVPA) Test Plan

Amphibious Combat Vehicle (ACV) Initial Operational Test Plan

Army Integrated Air and Missile Defense (AIAMD) Limited User Test and Adversarial Assessment Test Plan

Ballistic Missile Defense System (BMDS) Integrated Master Test Plan (IMTP) version 21.1

Blue Grass Chemical Agent Destruction Pilot Plant (BGCAPP) Test Evaluation Plan (TEP) for Operational Testing

Bradley M2A4/M7A4 Engineering Change Proposal 2a Follow-On Operational Test Operational Test Plan

Defense Enterprise Accounting Management System (DEAMS) Oracle R12 Software Upgrade, Increment 1 Follow-On Test and Evaluation Plan

Electronic Warfare Planning and Management Tool (EWPMT) Cooperative Vulnerability and Penetration Assessment (CVPA)

Extended Range Guided Multiple Launch Rocket System Rocket Test Design Plan

F-22 Release 1 Force Development Evaluation (FDE) Test Plan

F-35 Initial Operational Test and Evaluation (IOT&E) Test Plan Change Request for Electronic Attack Test Events

F-35 Modernization Block 4 Suitability Test Plan

FFG(X) Guided Missile Frigate Live Fire Test and Evaluation Alternate Plan

Global Command and Control System - Joint (GCCS-J) Version (v) 6.0.1.x Cyber Survivability Test Plan Annex

Global Positioning System III Space Vehicle/Contingency Operations (GPS III SV/COps) Operational Utility Evaluation (OUE) Test Plan

Handheld, Manpack, and Small Form Fit (HMS) Cooperative Vulnerability and Penetration Assessment (CVPA) Test Plan

High Altitude Anti-Submarine Warfare Weapon Capability (HAAWC) Test Plan

High Altitude Anti-submarine warfare Weapon Component (HAAWC) Cyber Test Plan

High Mobility Artillery Rocker System (HIMARS) Increased Crew Protection (ICP) Re-Start Live Fire Test Design Plan

Initial Maneuver Short Range Air Defense (IM-SHORAD) Cooperative Vulnerability Penetration Assessment (CVPA) Test Plan

Integrated Tactical Network (ITN) Cooperative Vulnerability and Penetration Assessment (CVPA) Test Plan

Joint Assault Bridge (JAB) IOT&E 2 Operational Test Plan

Limited Interim Missile Warning System Cybersecurity Cooperative Vulnerability and Penetration Assessment Test Plan

Littoral Combat Ship (LCS) Independence Variant Surface Warfare Mission Package Increment 3 Initial Operational Test and Evaluation Test Plan

M270A2 Improved Armored Cab (IAC) Live Fire Test Design Plan

M917A3 Heavy Dump Truck (HDT) Live Fire (LF) Test and Evaluation Change to the Test Design Plan

Military Health System (MHS) GENESIS Follow-On Operational Test and Evaluation (FOT&E) Plan

MK 54 Mod 1 Lightweight Torpedo Test Plan

Next Generation Jammer MID-Band AN/ALQ-249(V) Integrated Test, Data Collection Plan and Milestone C Report Test Plan

Over the Horizon Weapon System (OTH-WS) Initial Operational Test and Evaluation (IOT&E) Test Plan

RQ-4B Block Multi-Spectral Intelligence Operational Utility Evaluation Plan Deviation

RQ-7Bv2 Block III Shadow Tactical Unmanned Aircraft System Follow-On Operational Test Operational Test Plan

RQ-7Bv2 Tactical Unmanned Aircraft System (TUAS) Cooperative Vulnerability and Penetration Assessment Test Plan

Soldier Protection System Vital Torso Protection Generation III X Small Arms Protective Insert First Article Test Plan

Stryker Anti-tank Guided Missile (ATGM) Engineering Change Proposal (ECP) Cooperative Vulnerability and Penetration Assessment (CVPA) Test Plan

Stryker Anti-Tank Guided Missile (ATGM) Engineering Change Proposal Follow-on Operational Test Operational Test Plan

Tomahawk Modernization OT-D-12 Test Plan

TRIDENT II D5 Life Extension (D5LE) Demonstration and Shakedown Operations - 30 (DASO-30) Flight Test Support Plan for Operational Test and Evaluation

VH-92A Cyber Test Plan and Classified Annex

VH-92A Initial Operational Test and Evaluation Test Plan

Wide Area Surveillance (WAS) Initial Operational Test and Evaluation (IOTE) Plan

XM1147 Advanced Multi-Purpose (AMP) Armor Characterization Test Plan

XM1158 Advanced Armor Piercing (ADVAP) Test Plan

LIVE FIRE TEST AND EVALUATION STRATEGIES/MANAGEMENT PLANS

FFG(X) Guided Missile Frigate Live Fire Test and Evaluation Strategy

Initial Maneuver Short Range Air Defense (IM-SHORAD) Live Fire Test and Evaluation Strategy and Test Design Plan (TDP)

Maritime Strike Tomahawk (MST) Live Fire Test and Evaluation Strategy

UH-1N Replacement Program Alternative Live Fire Test and Evaluation Strategy

TABLE 1. FY20 REPORTS TO CONGRESS	
PROGRAM	**DATE**
Cybersecurity Reports	
Cyber Red Team Operations Classified Observations from Department of Defense Activities	September 2020
Early Fielding Reports	
Abrams M1A2 System Enhancement Package Version 2 (SEPv2) with Trophy Active Protection System (APS)	June 2020
Aegis Weapon System Advanced Capability Build (ACB) 16 Phase 0/Baseline 9A2A	March 2020
Over-the-Horizon Weapon System (OTH-WS)	February 2020
Follow-On Operational Test and Evaluation Reports	
Multi-static Active Coherent (MAC) System	September 2020
Military Health System (MHS) GENESIS	July 2020
Mobile User Objective System (MUOS)	October 2019
Version 6 of the AH-64E Apache Attack Helicopter II	October 2019
Initial Operational Test and Evaluation Reports	
Common Infrared Countermeasures (CIRCM)	September 2020
B61 Mod 12 Life Extension Program Tail Kit Assembly	September 2020
Littoral Combat Ship (LCS) with Increment 3 Surface Warfare (SUW) Mission Package	July 2020
Space-Based Infrared System (SBIRS) Block 20	July 2020
Space Fence Increment I	June 2020
Operational Assessment Report	
Integrated Visual Augmentation System (IVAS) Capability Set 2	May 2020
Special Reports	
Defense Enterprise Accounting and Management System Oracle Release 12 Software Upgrade	July 2020
Advanced Capability Build 2011 (ACB-11) Version of the AN/SQQ-89A(V)15 Surface Ship Undersea Warfare Combat System Cybersecurity Update to the December 2018 IOTE Report	March 2020
Hypersonic and Ballistic Tracking Space Sensor (HBTSS) Assessment of Test Strategy	March 2020
Assessment of Rapid Prototyping and Rapid Fielding Programs Test Strategies	February 2020
DOT&E Certification and Risk Assessment of Test Strategies for Navy Accelerated Acquisition Board of Directors (AA BoD) and Middle Tier Acquisition (804) Programs	January 2020
Ballistic Missile Defense System Report	
Fiscal Year 2019 Assessment of the Ballistic Missile Defense System (BMDS)	February 2020

TABLE 2. OTHER FY20 REPORTS (NOT SENT TO CONGRESS)	
PROGRAM	**DATE**
Cybersecurity Reports	
US INDO-PACIFIC COMMAND Cybersecurity Assessment	February 2020
U.S. European Command Cyber Readiness Campaign 2019 Green Team Summary	December 2019
2017-2019 Cybersecurity Assessment of Special Operations Command (USSOCOM)	December 2019
Early Fielding Report	
Distributed Aperture Infrared Countermeasures (DAIRCM) System	February 2020
Follow-on Operational Test and Evaluation Report	
E-2D Advanced Hawkeye (AHE) Delta System Software Configuration, Build 3 (DSSC-3) and Aerial Refueling	July 2020
Limited User Test Reports	
Public Key Infrastructure Increment 2	December 2019
Multi-Service Operational Test and Evaluation Report	
Small Diameter Bomb II (SDB II) Phase 1	July 2020
Operational Assessment Reports	
UH-60V Black Hawk	September 2020
Joint Air-to-Ground Missile (JAGM)	August 2020
Infantry Squad Vehicle (ISV)	June 2020
Joint Light Tactical Vehicle (JLTV) Family of Vehicles (FoV)	February 2020
Surface Mine Countermeasure Unmanned Undersea Vehicle (SMCM UUV) Program Knifefish OT-B1	January 2020
MQ-4C Triton OT-C1	December 2019
Defense Agencies Initiative (DAI) Increment 3 Release 1	November 2019
Global Command and Control System - Joint (GCCS-J) Operations Version 6.0.1.2	November 2019
Operational Test and Evaluation Reports	
Distributed Common Ground System – Army Capability Drop 1	April 2020
Quick Reaction Assessment Report	
Offensive Anti-Surface Warfare (OASuW) Increment 1 Long Range Anti-Ship Missile (LRASM)	March 2020

Program Oversight

Per section 139, title 10, United States Code, DOT&E is the principal adviser to the Secretary of Defense and the Under Secretaries of Defense for Acquisition and Sustainment, and Research and Engineering. The Director is responsible for monitoring and reviewing all operational and live fire test and evaluation activities of the DOD. DOT&E selects a program for operational and/or live fire test and evaluation oversight if it meets one or more of the following criteria:

- Program exceeds or has the potential to exceed the dollar value threshold for a major program, to include Major Defense Acquisition Programs (MDAPs), designated major subprograms, as well as highly classified programs and pre-MDAPs.
- Program has a high level of Congressional or DOD interest.
- Weapons, equipment, or munitions that provide or enable a critical mission warfighting capability or is a militarily significant change to a weapon system.

In FY20, using these criteria, DOT&E monitored 228 acquisition programs for operational test and evaluation and 83 acquisition programs for live fire test and evaluation.

DOD PROGRAMS

5th Generation Aerial Target

AC-130J

BMDS - Ballistic Missile Defense System Program

Defense Agencies Initiative (DAI)

Defense Enterprise Accounting and Management System - Increment 1 (DEAMS - Inc. 1)

Defense Enterprise Office Solution (DEOS)

Defense Medical Information Exchange (DMIX)

Defense Security Assistance Management System (DSAMS) - Block 3

Digital Modernization Infrastructure (DMI)

DoD Healthcare Management System Modernization (DHMSM)

Global Command & Control System - Joint (GCCS-J)

Joint Light Tactical Vehicle Family of Vehicles

Joint Operational Medicine Information Systems

Joint Regional Security Stack (JRSS)

Key Management Infrastructure (KMI)

Long-Range Discrimination Radar

milCloud

Public Key Infrastructure (PKI) Inc. 2

SOCOM Dry Combat Submersible Medium (DCSM)

Teleport, Generation III

Theater Medical Information Program - Joint (TMIP-J) Block 2

ARMY PROGRAMS

120MM Advanced Multi-Purpose (AMP), XM1147

3rd Generation Improved Forward Looking Infrared (3rd Gen FLIR)

Abrams M1A1 SA; M1A2 SEP; APS

Advanced Field Artillery Tactical Data System (AFATDS) Version 7

Advanced Threat Detection System

Aerosol and Vapor Chemical Agent Detector

AH-64E Apache Remanufacture/New Build

AN/TPQ-53 Radar System (Q-53)

Armored Multipurpose Vehicle (AMPV)

Armored Truck - Heavy Equipment Transporter (HET)

Army Contract Writing System

Army Integrated Air & Missile Defense (AIAMD)

Assured - Positioning, Navigation, & Timing (Assured - PNT)

Biometrics Enabling Capability (BEC) Increment 1

Biometrics Enabling Capability Increment 0

Black Hawk (UH-60M) - Utility Helicopter Program

Bradley ECP; MOD; APS

Cannon Delivered Area Effects Munitions (C-DAEM) Family of Munitions

CH-47F Block II Chinook

Command Post Computing Environment (CPCE), to include the Tactical Server Infrastructure (TSI) and supporting functions hosted on the TSI

Common Infrared Countermeasures (CIRCM)

Distributed Common Ground System - Army (DCGS-A)

Electronic Warfare Planning and Management Tool (EWPMT)

EXCALIBUR - Family of Precision, 155 mm Projectiles

Extended Range Cannon Artillery (ERCA)

Family of Medium Tactical Vehicles A2 (FMTV A2)

Future Vertical Lift (FVL) Future Unmanned Aircraft System (FUAS)

Future Vertical Lift (FVL) Future Long Range Assault Aircraft (FLRAA)

Global Combat Support System Army (GCSS-A)

Ground Mobility Vehicle 1.1 (GMV 1.1)

Guided Multiple Launch Rocket System Family of Munitions Including Alternative Warhead (AW); Unitary; Extended Range (ER)

Handheld, Man pack, and Small Form Fit (including Handheld and Manpack components)

Heavy Dump Truck

HELLFIRE

High Mobility Artillery Rocket System (HIMARS)

Identification Friend or Foe Mark XIIA Mode 5 (all development and integration programs)

Improved High Explosive Dual Purpose 40mm Cartridge

Improved Turbine Engine Program (ITEP)

Indirect Fire Protection Capability Increment 2 - Intercept (IFPC Inc 2-I)

Integrated Personnel and Pay System - Army (IPPS-A) Increment 2

Integrated Tactical Network (ITN)

Integrated Visual Augmentation System (IVAS)

Javelin Antitank Missile System - Medium

Joint Air-to-Ground Missile (JAGM)

Joint Assault Bridge (JAB)

Joint Battle Command Platform (JBC-P)

Joint Biological Tactical Detection System

Limited Interim Missile Warning System

Logistics Modernization Program (LMP)

Lower Tier Air and Missile Defense Sensor

M270A1 Multiple Launch Rocket System (MLRS)

M88 series of heavy recovery vehicles (Hercules)

Maneuver-Short Range Air Defense

Mobile / Handheld Computing Environment (M/HCE)

Mobile Protected Firepower Increment 1 (MPF Inc 1)

Mounted Computing Environment (MCE) to include hardware, software, network and transport components

Multi-Function Electronic Warfare (MFEW) Air Large

Near Real Time Identity Operations

Nett Warrior

Next Generation Combat Vehicle (NGCV) Optionally Manned Fighting Vehicle (OMFV)

Next Generation Squad Weapons (NGSW)

Paladin/FASSV Integrated Management (PIM)

PATRIOT PAC-3 - Patriot Advanced Capability 3

Precision Guidance Kit Family of Fuzes

Precision Strike Missile (PrSM)

RQ-7B SHADOW - Tactical Unmanned Aircraft System

Soldier Protection System

Stryker Family of Vehicles to include all variants (including NBCRV)

Terrain Shaping Obstacles (TSO)

UH-60V Black Hawk

XM1158 7.62 mm Cartridge

NAVY PROGRAMS

Acoustic Rapid COTS Insertion for SONAR

Advanced Airborne Sensor

Advanced Arresting Gear

AEGIS Modernization (Baseline Upgrades)

AGM-88G Advanced Anti-Radiation Guided Missile Extended Range

AIM-9X - Air-to-Air Missile Upgrade Block II

Air and Missile Defense Radar (AMDR) / AN/SPY-6

Air Warfare Ship Self Defense Enterprise

Amphibious Combat Vehicle (ACV) Family of Vehicles (FoV)

AN/AQS-20X Minehunting Sonar and Tow Vehicle (all variants)

AN/SQQ-89A(V) Integrated USW Combat Systems Suite

Assault Breaching System Coastal Battlefield Reconnaissance and Analysis System (all variants)

Barracuda Mine Neutralization System

Consolidated Afloat Networks and Enterprise Services (CANES)

Carrier Based Unmanned Air System

CH-53K - Heavy Lift Replacement Program

CMV-22 Joint Services Advanced Vertical Lift Aircraft - Osprey – Carrier Onboard Delivery (COD)

Columbia Class SSBN - including all supporting PARMs

Cooperative Engagement Capability (CEC)

CVN-78 - *Gerald R. Ford* Class Nuclear Aircraft Carrier

DDG 1000 - *Zumwalt* Class Destroyer and associated PARMs

DDG 51 Flight III and associated PARMS

Distributed Aperture Infrared Countermeasure (DAIRCM) System

Distributed Common Ground System - Navy (DCGS-N)

E-2D Advanced Hawkeye

Electro-Magnetic Aircraft Launching System

Enterprise Air Surveillance Radar

Evolved Sea Sparrow Missile Block 2

F/A-18E/F - SUPER HORNET Naval Strike Fighter

FFG(X) - Guided Missile Frigate

Ground/Air Task Oriented Radar (G/ATOR)

Identification Friend or Foe Mark XIIA Mode 5 (all development and integration programs)

Infrared Search and Track System

LHA 6 Flt 0 and associated PARMs

LHA 6 Flt I and associated PARMs

Light Armored Vehicle

Littoral Combat Ship (LCS) Anti-Submarine Warfare (ASW) Mission Package to include all associated vehicles, communications, sensors, weapon systems, support equipment, software, & support aircraft that are in development

Littoral Combat Ship (LCS) Mine-Countermeasures (MCM) Mission Package to include all associated vehicles, communications, sensors, weapon systems, support equipment, software, and support aircraft that are in development

Littoral Combat Ship (LCS), *Freedom* and *Independence* Variant Seaframes

Littoral Combat Ship (LCS) Surface Warfare (SUW) Mission Package to include all associated vehicles, communications, sensors, weapon systems, support equipment, software, & support aircraft in development, 30mm, SSMM/Longbow HELLFIRE/ammunition lethality

LPD 17 Flt II

MK 54 torpedo/MK - 54 VLA/MK 54 Upgrades Including High Altitude ASW Weapon Capability (HAAWC)

MK-48 CBASS Torpedo including all upgrades

Mobile Advanced Extremely High Frequency Terminal

Mobile User Objective System (MUOS)

MQ-4C Triton

MQ-8 Fire Scout Unmanned Aircraft System

Multi-Functional Information Distribution System (includes integration into USAF & USN aircraft)

Multi-static Active Coherent (MAC) System

MV-22 Joint Services Advanced Vertical Lift Aircraft - Osprey

Naval Integrated Fire Control - Counter Air (NIFC-CA) From the Air

Navy Expendable Airborne Electronic Attack (EA2)

Navy Maritime Maintenance Enterprise Solution - Technical Refresh

Navy Personnel and Pay System

Next Generation Jammer - Increment 1 (Mid-Band)

Next Generation Jammer - Increment 2 (Low Band)

Offensive Anti-Surface Warfare Increment 1 Long Range Anti-Ship Missile

Offensive Anti-Surface Warfare, Increment 2 (Air and Surface Launch)

Over The Horizon Weapon System

Rolling Airframe Missile Block 2 Program

RQ-21A Unmanned Aircraft System (UAS)

Ship Self Defense System (SSDS)

Ship to Shore Connector

Standard Missile 2 (SM-2) including all mods

Standard Missile-6 (SM-6)

Submarine Torpedo Defense System (Sub TDS) including Next Generation Countermeasure System (NGCM)

Surface Electronic Warfare Improvement Program Block 2

Surface Electronic Warfare Improvement Program Block 3

Surface Mine Countermeasures Unmanned Undersea Vehicle (also called Knifefish UUV) (SMCM UUV)

Tactical Tomahawk Modernization and Enhanced Tactical Tomahawk (Maritime Strike) (includes changes to planning and weapon control system)

T-AO 205 Oiler

TRIDENT II MISSILE - Sea Launched Ballistic Missile

Unmanned Influence Sweep System (UISS) include Unmanned Surface Vessel (USV) and Unmanned Surface Sweep System (US3)

VH-92A Presidential Helicopter

Virginia Class SSN (all variants)

AIR FORCE PROGRAMS

Advanced Pilot Trainer

Advanced Extremely High Frequency (AEHF) Satellite Program

AIM-120 Advanced Medium-Range Air-to-Air Missile

Air Force Integrated Personnel and Pay System (AF-IPPS)

Air Force Maintenance, Repair and Overhaul Initiative (MROi)

Air Operations Center - Weapon System (AOC-WS)

Air-Launched Rapid Response Weapon

B-2 Defensive Management System Modernization (DMS-M)

B-21 Long Range Strike Bomber

B-52 Commercial Engine Replacement Program (CERP)

B-52 Radar Modernization Program (RMP)

B61 Mod 12 Life Extension Program Tail Kit Assembly

C-130J - HERCULES Cargo Aircraft Program

Deliberate and Crisis Action Planning and Execution Segments (DCAPES) Inc. 2B

Enhanced Polar System Recapitalization (EPS-R)

Evolved Strategic Satellite Communcations

F-15 Eagle Passive Active Warning Survivability System

F-15C Infrared Search and Track (IRST)

F-15EX

F-16 Radar Modernization Program

F-22 - RAPTOR Advanced Tactical Fighter

F-35 - Lightning II Joint Strike Fighter (JSF) Program

Family of beyond Line-of-Sight Terminals (FAB-T)

Geosynchronous Space Situational Awareness Program

Global Positioning System (GPS) Enterprise Oversight

Global Positioning System (GPS) III Space Vehicle

Global Positioning System (GPS) Next Generation Operational Control System

Ground Based Strategic Deterrent

HH-60W Jolly Green II

Hypersonic Conventional Strike Weapon

Identification Friend or Foe Mark XIIA Mode 5 (all development and integration programs)

Integrated Strategic Planning and Analysis Network (ISPAN) Increment 4

Integrated Strategic Planning and Analysis Network Increment 5

Joint Air-to-Surface Standoff Missile Electronic Safe Arm and Fuze
Joint Cyber Warfighting Architecture – Joint Cyber Command and Control
Joint Cyber Warfighting Architecture – Unified Platform
Joint Space Operations Center Mission System (JMS)
KC-46 - Tanker Replacement Program
Long Range Stand Off (LRSO) Cruise Missile
Massive Ordnance Penetrator (MOP)
MH-139A Grey Wolf
Military Global Positioning System (GPS) User Equipment
Military Personnel Data System
Mission Partner Environment (MPE)
Next Generation Overhead Persistant Infrared
Nuclear Planning and Execution System
Presidential National Voice Conferencing
Protected Tactical Enterprise Service
Protected Tactical Satellite Communcations (SATCOM)
RQ-4 Global Hawk Unmanned Aircraft System Multi-Spectrum-177 Sensor
Space-Based Infrared System Program (SBIRS)
Space-Based Infrared System (SBIRS) Survivable and Endurable Evolution (S2E2)
Space Fence (SF)
Small Diameter Bomb Increment II
Space Command and Control System
Stand In Attack Weapon (SiAW)
Three-Dimensional Expeditionary Long-Range Radar (3DELRR)
United States Air Force Survivable Airborne Operations Center
VC-25B Presidential Aircraft
Weather Satellite Follow-on (WSF)
Wide Area Surveillance (WAS)

Coronavirus (COVID-19) Pandemic Impacts to T&E

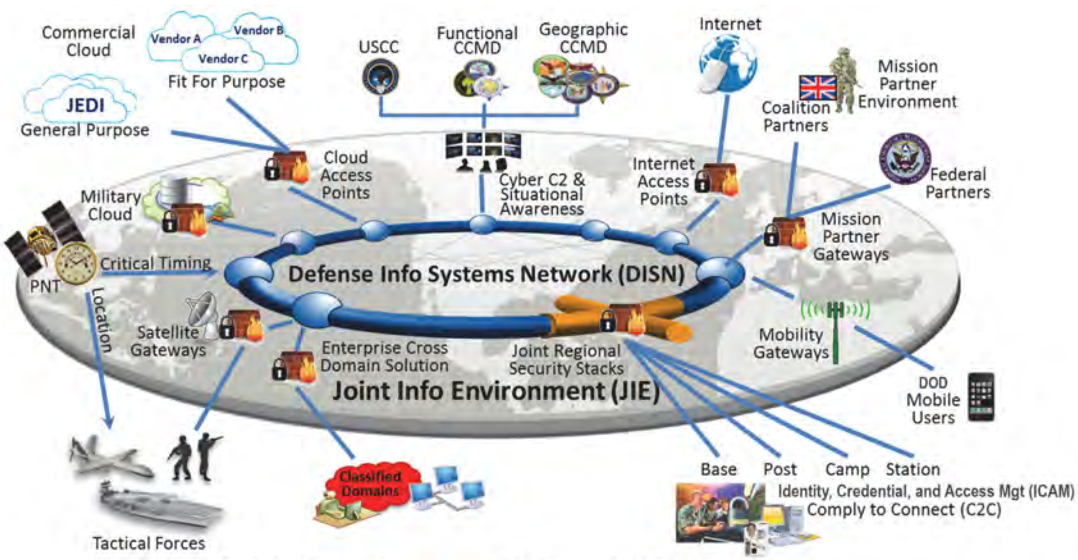
Table 1 lists the 75 programs on DOT&E oversight that experienced impacts to T&E due to the coronavirus (COVID-19) pandemic in FY20. Those programs marked with an asterisk have individual articles in the book with more information.

TABLE 1. PROGRAMS IMPACTED BY COVID-19 IN FY20	
120-mm Advanced Multi-Purpose (AMP), XM1147*	Global Positioning System (GPS) Next Generation Operational Control System*
5th Generation Aerial Target	Guided Multiple Launch Rocket System Family of Munitions Including Alternative Warhead (AW); Unitary; Extended Range (ER)*
AC-130J*	Handheld, Man pack, and Small Form Fit (including Handheld and Manpack components)
Aegis Modernization (Baseline Upgrades)*	HH-60W Jolly Green II*
Aerosol and Vapor Chemical Agent Detector*	Integrated Tactical Network (ITN)*
AGM-88G Advanced Anti-Radiation Guided Missile Extended Range	Integrated Visual Augmentation System (IVAS)*
Air Operations Center - Weapon System*	Joint Assault Bridge (JAB)*
Amphibious Combat Vehicle (ACV) Family of Vehicles (FoV)*	Joint Biological Tactical Detection System
Armored Multipurpose Vehicle (AMPV)*	Joint Light Tactical Vehicle Family of Vehicles*
Army Integrated Air & Missile Defense (AIAMD)*	Joint Regional Security Stack (JRSS)*
Assured – Positioning, Navigation, & Timing (Assured - PNT)*	KC-46 – Tanker Replacement Program*
B-21 Long Range Strike Bomber	Littoral Combat Ship (LCS), *Freedom* and *Independence* Variant Seaframes
B61 Mod 12 Life Extension Program Tail Kit Assembly*	Maneuver-Short Range Air Defense*
Biometrics Enabling Capability Increment 0	MH-139A Grey Wolf*
Black Hawk (UH-60M) – Utility Helicopter Program	MK 54 torpedo/MK - 54 VLA/MK 54 Upgrades Including High Altitude ASW Weapon Capability (HAAWC)*
BMDS - Ballistic Missile Defense System Program*	Mobile / Handheld Computing Environment (M/HCE)
Bradley ECP; MOD; APS*	Mobile Protected Firepower Increment 1 (MPF Inc 1)
Carrier Based Unmanned Air System	Multi-Functional Information Distribution System (includes integration into USAF & USN aircraft)
CH-47F Block II Chinook*	MV-22 Joint Services Advanced Vertical Lift Aircraft – Osprey
CMV-22 Joint Services Advanced Vertical Lift Aircraft - Osprey – Carrier Onboard Delivery (COD)*	Nett Warrior
Columbia Class SSBN – including all supporting PARMs	Next Generation Jammer – Increment 1 (Mid-Band)*
Common Infrared Countermeasures (CIRCM)*	Next Generation Jammer – Increment 2 (Low Band)
DDG 1000 – *Zumwalt* Class Destroyer and associated PARMs	PATRIOT PAC-3 – Patriot Advanced Capability 3*
DDG 51 Flight III and associated PARMS	Public Key Infrastructure (PKI) Incr 2*
Defense Enterprise Accounting and Management System - Increment 1 (DEAMS - Inc. 1)*	Ship to Shore Connector
Deliberate and Crisis Action Planning and Execution Segments (DCAPES) Inc. 2B	Small Diameter Bomb, Increment II*
Digital Modernization Infrastructure (DMI) formerly Joint Information Environment (JIE)*	SOCOM Dry Combat Submersible Medium (DCSM)
Distributed Aperture Infrared Countermeasure (DAIRCM) System*	Soldier Protection System*
Distributed Common Ground System – Army (DCGS-A)	Space Command & Control (Space C2)
DoD Healthcare Management System Modernization (DHMSM)*	Stryker Family of Vehicles to include all variants (including NBCRV)*
Evolved Sea Sparrow Missile Block 2	Tactical Tomahawk Modernization and Enhanced Tactical Tomahawk (Maritime Strike) (includes changes to planning and weapon control system)
Extended Range Cannon Artillery (ERCA)	T-AO 205 Oiler
F-15C Infrared Search and Track (IRST)	TRIDENT II MISSILE – Sea Launched Ballistic Missile
F-22 – RAPTOR Advanced Tactical Fighter	UH-60V Black Hawk*
F-35 – Lightning II Joint Strike Fighter (JSF) Program*	VH-92A Presidential Helicopter*
FAB-T – Family of beyond Line-of-Sight Terminals	*Virginia* Class SSN (all variants)
Family of Medium Tactical Vehicles A2 (FMTV A2)*	XM1158 7.62 mm Cartridge*
Global Command & Control System – Joint (GCCS-J)*	

DOD Programs

DOD Programs

Digital Modernization Strategy (DMS) – Related Enterprise Information Technology Initiatives



CCMD – Combatant Command
C2C – Comply to Connect
DOD – Department of Defense
JIE – Joint Information Environment
PNT - Positioning, Navigation and Timing
C2 – Command and Control
DISN – Defense Information Systems Network
JEDI - Joint Enterprise Defense Infrastructure
ICAM – Identity, Credential, and Access Management
USCC – United States Cyber Command

Executive Summary

- In 2020, the DOD Chief Information Officer (CIO) subsumed the Joint Information Environment (JIE) into the broader DOD Digital Modernization Strategy (DMS). The DOD CIO approved the Digital Modernization Infrastructure (DMI) Executive Committee (EXCOM) Charter that formalized governance, roles, and responsibilities for implementing select strategy elements of the DMS.
- The DOD CIO approved the DOD Identity, Credential, and Access Management (ICAM) Strategy in March 2020 to implement a trusted environment for person and non-person entities to securely access authorized information technology (IT) resources.
- Due to the coronavirus (COVID-19) pandemic, the DOD CIO implemented the Commercial Virtual Remote (CVR) environment as an interim solution to support expanded DOD teleworking from April to December 2020.
- In September 2020, the SECDEF approved the CVR extension through June 2021 under the Coronavirus Aid, Relief, and Economic Security (CARES) Act.
- The DOD and Services are establishing Microsoft (MS) 365 environments as replacements for CVR, and the Defense Information Systems Agency (DISA) intends to establish a DOD 365 environment for the 4th Estate and some Combatant Commands.
- DOT&E continues to stress the need for the DOD to conduct threat-representative cybersecurity testing on commercial cloud platforms to be used by the Defense Enterprise Office Solution (DEOS).

Systems

- In August 2012, the Joint Chiefs of Staff (JCS) approved the JIE concept as a secure environment, comprising a single security architecture, shared IT infrastructure, and enterprise services.
- The JCS intended JIE to consist of multiple subordinate programs, projects, and initiatives managed and implemented by DISA and the Military Services.
- In January 2017, the JIE EXCOM approved 10 JIE capability objectives.
- In 2020, the DOD CIO realigned JIE with the DOD DMS and mapped the JIE capability objectives executed under the auspices of JIE EXCOM to the relevant DMS elements.
- In July 2020, the DOD CIO chartered the DMI EXCOM to provide oversight of the DMS elements below:
  - Modernize Warfighter Command, Control, Communication, and Computer Infrastructure and Systems
  - Modernize Defense Information Systems Network Transport Infrastructure
  - Modernize and Optimize DOD Component Networks and Services
  - Shift from Component-Centric to Enterprise-Wide Operations and Defense Model

- Strengthen Collaboration, International Partnerships, and Allied Interoperability
- Optimize Data Centers Infrastructure
- Transform the DOD Cybersecurity Architecture to Increase Agility and Strengthen Resilience
- Ensure Cybersecurity Risks are Planned for and Managed Throughout the Acquisition Lifecycle
- Expand the Use of Proven Software and Hardware Assurance Methods
- Deliver a DOD Enterprise Cloud Environment to Leverage Commercial Innovation
- Deploy an End-to-End ICAM Infrastructure
- Improve Information Sharing to Mobile Users
- Improve IT Category Management
- Optimize DOD Office Productivity and Collaboration Capabilities (Enterprise Collaboration and Productivity Services (ECAPS) Capability Set 1)
- Optimize DOD Voice and Video Capabilities (ECAPS Capability Sets 2 and 3)

• DMS is not a program of record, and the DMI EXCOM does not have traditional milestone decision authorities. DMS elements are addressed through Service and DISA programs of record and other funded initiatives.
• The DOD CIO is the overall lead for DMS efforts with support from the DMI EXCOM – chaired by the DOD CIO, U.S. Cyber Command, and Joint Staff J6. The EXCOM provides guidance, direction, and oversight of the development, execution, and utilization of DOD enterprise infrastructure. DISA is the principal integrator for DOD Information Networks enterprise capabilities, enabling initiatives, and testing.
• DOT&E is concerned with the cyber survivability of DMS initiatives and less so with their operational effectiveness and suitability.

Activity

Overall

• For the Joint Regional Security Stack updates, see the article on page 37.
• In 2020, the DOD CIO subsumed the JIE into the broader DOD DMS.
• In July 2020, the DOD CIO approved the DMI EXCOM Charter that formalized governance, roles, and responsibilities for implementing select strategy elements of the DMS.
• The DMI EXCOM continued to provide guidance and direct the implementation of the funded initiatives supporting the DMS for the DOD.
• In 2020, the DOD CIO added DOT&E, the Principal Cyber Advisor, and the USD(R&E) as DMI EXCOM members.

ECAPS

• The General Services Administration awarded the DEOS Blanket Purchase Agreement in October 2020.
• Due to COVID-19, the DOD CIO implemented the CVR environment as an interim solution to support expanded DOD teleworking from April to December 2020.
• In September 2020, the SECDEF approved the CVR extension through June 2021 under the CARES Act.
• The DOD and Services are establishing MS 365 environments as replacements for CVR, and DISA intends to establish a DOD 365 environment for the 4th Estate and some Combatant Commands.
• In coordination with the DOD CIO, the USD(A&S) is evaluating and refining the ECAPS capability sets 2 and 3 requirements through 2020.
• DOT&E is coordinating a cybersecurity risk assessment of four Service-led Zero Trust Office 365 Pilot efforts to help inform the Zero Trust technology options for the DOD Federated Office 365 effort. The Zero Trust concept potentially provides significant cybersecurity improvements, if implemented properly.

End Point Security

• In 2020, the Joint Interoperability Test Command (JITC) plan to evaluate two suites of end point security capabilities for DMI EXCOM decision was delayed due to lack of Service support.
• In October 2020, JITC halted the end point security operational assessments to support MS 365 pilot testing.

ICAM

• In March 2020, the DOD CIO approved the DOD ICAM Strategy to implement a trusted environment for person and non-person entities to securely access authorized IT resources.
• The DOD CIO established the Joint Program Integration Office to coordinate ICAM efforts across the Department and with Services and Agencies.
• In June 2020, DISA awarded the ICAM enterprise pilots contract.

Mission Partner Environment (MPE)

• In March 2020, the Under Secretary of Defense for Intelligence and Security, DOD CIO, and Joint Staff issued guidance for information sharing with mission partners in support of globally integrated operations. The MPE capability framework is intended to be used by the U.S. Joint Force to share information with mission partners from the strategic to the tactical levels.
• The DOD CIO is updating the overarching MPE governance policy in 2020/2021.
• The intent is to rationalize and modernize the overall MPE portfolio of command and control, and intelligence information sharing capabilities.
• MPE is intended to consolidate and recapitalize 28 physical Combined Enterprise Regional Information Exchange Systems across the DOD, providing virtualized enduring and episodic MPE services tailored to meet mission partner information sharing needs.

Assessment

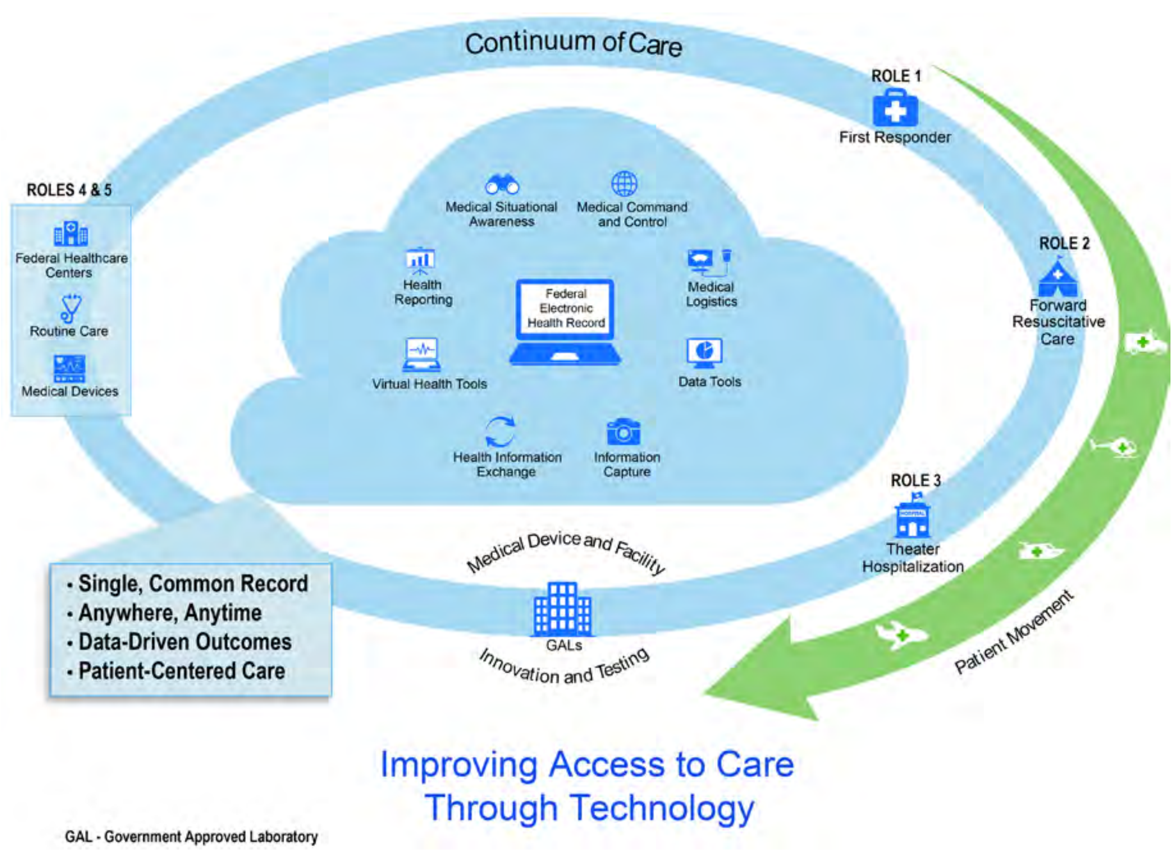
- The DOD CIO, DISA, and Services intend to achieve the DMS objectives through implementation of enabling initiatives aligned under the DMI EXCOM approved and funded priorities.
- The DEOS schedule was delayed due to contract award problems in FY20 and by DOD efforts to implement a commercial cloud Impact Level (IL-5) federated environment, due to COVID-19.
- Because the DEOS program plans to use commercial cloud platforms to store classified and unclassified data, it will be critical for the DOD to conduct threat-representative cybersecurity testing on the commercial cloud and its hosting infrastructure. This will require appropriate agreements between the DOD and chosen cloud service providers.
- The DOD, DISA, and JITC lack a funded and consolidated test forum for addressing DMS enterprise information technology initiatives.

Recommendations

The DOD CIO, DMI EXCOM, Services, and Director of DISA should:

1. Conduct thorough cybersecurity operational testing of all DMS enterprise initiatives, including threat-representative testing of the commercial cloud capabilities employing current cybersecurity testing guidance and policy.
2. Use operational test data, analyses, and reporting to inform DMI EXCOM decisions.
3. Institute and facilitate remote testing capabilities as a requirement for DMI EXCOM-sponsored efforts to facilitate adequate testing under COVID-19 restrictions.
4. Update the DEOS Test and Evaluation Master Plan (TEMP) based on the contract award and the master schedule for the planned NIPRNET and SIPRNET deliveries.
5. Develop a TEMP for ECAPS current and future capability sets 2 and 3, and more generally for each funded DMS enterprise initiative.
6. Fund JITC to fully support DMS enterprise initiatives, testing, and test-related forums.

DoD Healthcare Management System Modernization (DHMSM®)



Executive Summary

- MHS GENESIS is intended to transform the way the DOD and the Department of Veterans Affairs (VA) provide military and veteran healthcare missions by creating a single health care record for each patient, used by both agencies.
- The Joint Interoperability Test Command (JITC), with Service Operational Test Agency (OTA) assistance, conducted an MHS GENESIS FOT&E during January and February 2020 at four operational Military Medical Treatment Facilities (MTFs) in California and Idaho.
  - MHS GENESIS is operationally effective for basic operations in conventional clinics, but is not operationally effective for certain specialty clinics and business areas. MHS GENESIS demonstrated improvement in performance compared to the July 2018 IOT&E. The MHS GENESIS software still needs work in the areas of medical readiness, provider referrals, business intelligence, billing, coding, and reporting.
  - During the FOT&E, information exchange with required external systems was sporadic, and patient data in MHS GENESIS were sometimes inaccurate and incomplete.
  - MHS GENESIS is not operationally suitable because training remains unsatisfactory, dissemination of system change information is inadequate, and usability problems persist.
  - JITC completed MHS GENESIS cybersecurity testing in September 2020. Compared to previous testing, cyber defenders were more effective in detecting Naval Information Warfare Center (NAVWAR) Red Team attacks and taking appropriate action to contain the attackers. However, MHS GENESIS is still not survivable in the complex, cyber-contested environment of a major medical facility.
  - The Defense Health Agency (DHA) created a Persistent Cyber Operations (PCO) program on August 13, 2020, to emulate a continuous cyber threat against MHS GENESIS, the Medical Community of Interest network, and interfacing systems. This innovative program is one of the best ways to assess and improve the cyber defenses of MHS GENESIS.

- After a pause in deployments following the FOT&E and the coronavirus (COVID-19) pandemic restrictions, the DHA began fielding MHS GENESIS to additional medical facilities in September 2020. The program has not yet determined when it will conduct the additional operational testing recommended in DOT&E's FOT&E report.

System

- The Program Office plans to field MHS GENESIS, a modernized Electronic Health Records system, to 205,000 MHS personnel providing care for 9.6 million DOD beneficiaries worldwide. MHS facilities encompass 54 hospitals, 377 medical clinics, and 270 dental clinics.
- MHS GENESIS comprises three major elements:
  - The Millennium suite of applications, developed by Cerner, which provides medical capabilities
  - Dentrix Enterprise, developed by Henry Schein, Inc., which provides dental capabilities
  - Orion Rhapsody Integration Engine, developed by Orion Health, which enables the majority of the external information exchanges
- The Joint Longitudinal Viewer (JLV) bridges medical records between the legacy systems and MHS GENESIS for the DOD, in addition to providing access to both DOD and VA medical records. JLV is a web-based application that displays a patient's entire medical record, organized by information type (e.g., allergies, medications, immunizations) in a single view.
- MHS GENESIS will replace legacy healthcare systems including the Armed Forces Health Longitudinal Technology Application (AHLTA), Composite Health Care System (CHCS), and Essentris inpatient system. MHS GENESIS will replace or modernize operational medicine components of the Theater Medical Information Program (TMIP) – Joint software suite.

Mission

DOD medical staff will use MHS GENESIS to manage delivery of dentistry, emergency department, immunization, laboratory, radiology, operating room, pharmacy, vision, audiology, and inpatient/outpatient services. DOD medical staff will also use MHS GENESIS to perform administrative support, front desk operations, logistics, billing, and business intelligence.

Major Contractors

- Leidos – Reston, Virginia
- Cerner – Kansas City, Missouri
- Accenture Federal Services – Arlington, Virginia
- Henry Schein, Inc. – Melville, New York

Activity

- JITC conducted an FOT&E of MHS GENESIS Block 2 during January and February 2020 at David Grant Medical Center (DGMC), Travis AFB, California; U.S. Army Health Clinic, Presidio of Monterey, California; Naval Health Clinic Lemoore, Naval Air Station Lemoore, California; and 366th Medical Clinic, Mountain Home AFB, Idaho, with the assistance of the military Services' operational test agencies. The FOT&E was conducted in accordance with a DOT&E-approved test plan.
- The Program Office installed Block 2.5 Millennium enhancements on March 27, 2020. Block 2.5 implemented capabilities required to support the VA's Capability Set 1 and enhancements to Radiology and Emergency Medicine.
- The Program Office installed Capability Block 3 on August 7, 2020. Block 3 implemented the Cerner Millennium Upgrade 2018.03; capabilities to support VA's Capability Set 2; and other system enhancements.
- The DHA created a PCO program on August 13, 2020, to emulate a continuous cyber threat against MHS GENESIS, the Medical Community of Interest network, and interfacing systems. The innovative program will assess the cyber posture of MHS GENESIS and the effectiveness of network tools, cyber defense tools, and cyber defender processes, and is one of the best ways to improve the program's defenses against nation state-level threats.
- JITC and NAVWAR conducted a cooperative vulnerability and penetration assessment (CVPA) at the Cerner Technology Center, Kansas City, Missouri, from July 29 to August 9, 2019, a second CVPA at DGMC, Travis AFB, California, from January 6-24, 2020, and an adversarial assessment (AA) encompassing both locations from August 17 to September 1, 2020. The CVPAs and AA were conducted in accordance with a DOT&E-approved test plan.
- The Program Office deployed MHS GENESIS to four Coast Guard pilot sites in California on August 29, 2020. Sites included Base Alameda Clinic, California; Air Station Sacramento Clinic, California; Training Center Petaluma Clinic, California; and the Maritime Safety and Security Team San Francisco Sickbay, California.
- JITC started remote verification of open IOT&E Incident Reports (IRs) on September 8, 2020. This testing was delayed by 4 months due to COVID-19 restrictions.
- The Program Office deployed MHS GENESIS at Weed Army Community Hospital, Fort Irwin, California; Naval Hospital Twentynine Palms, California; Beale AFB Clinic, California; Edwards AFB Clinic, California; Mike O'Callaghan Military Medical Center, Nellis AFB, Nevada; Los Angeles AFB Clinic, California; Vandenberg AFB Clinic, California; Naval Air Station Fallon Clinic, Nevada; Port Hueneme Clinic, California; and 1st Dental Battalion, Camp Pendleton, California, on September 26, 2020. These sites were designated "Wave Nellis" sites. The deployment was delayed by 3 months due to COVID-19 restrictions.

Assessment

- JITC, with Service OTA assistance, conducted the FOT&E at four operational MTFs in California and Idaho. During the FOT&E, operational testers observed users performing their day-to-day tasks at the MTFs while staff from DOT&E monitored the activity.
  - MHS GENESIS is operationally effective for basic operations in conventional clinics, but is not operationally effective for certain specialty clinics and business areas. MHS GENESIS demonstrated improvement in performance compared to the July 2018 IOT&E. Users successfully completed 78 percent of tested measures of performance, compared to only 45 percent completed at Madigan Army Medical Center, Washington, during IOT&E Phase 2. The commercial off-the-shelf software needs improvement in the areas of medical readiness, provider referrals, business intelligence, billing, coding, and reporting. Users frequently did not understand how the new MHS GENESIS workflows and local workarounds affect operations at the enterprise level, further limiting operational effectiveness.
  - Users generated 202 new IRs during the FOT&E; IRs document mission failure, degradation of mission capabilities, or inconveniences using the system. One quarter of these were high priority, indicating complete or partial mission failure. JITC confirmed closure for 80 percent of the retested IOT&E IRs, a significant achievement for both the Program Office and the operational testers. Following the FOT&E, JITC validated the closure of 11 IRs in September and October 2020. MHS GENESIS currently has 158 open high-priority IRs, 44 generated during the FOT&E, and 114 from the previous IOT&E.
  - During the FOT&E, information exchange with required external systems was sporadic, and the data were sometimes inaccurate and incomplete. Thirteen percent of patient allergy, immunization, and medication data did not transfer correctly to MHS GENESIS from the AHLTA and other legacy systems. The dates for some transferred data were incorrect. A training deficiency resulted in providers not routinely reconciling the MHS GENESIS information with legacy systems or with patients at their first encounter using MHS GENESIS to verify that patient information transferred was complete and accurate. When providers did reconcile data manually, the result was often a delay to patient care as providers needed to review data in the JLV, AHLTA, and other systems to obtain a complete health profile of the patient. MHS GENESIS and AHLTA users often could not see all required patient information using the JLV, eroding user trust in both MHS GENESIS and the JLV. The VA may experience similar interoperability problems when MHS GENESIS fielding begins in VA medical facilities.
  - MHS GENESIS is not operationally suitable because training remains unsatisfactory, dissemination of system change information is inadequate, and usability problems persist. Training and site preparation were not sufficient to support MHS GENESIS use at Go-Live. Lack of training on new workflows and operating in the enterprise environment mirrored weaknesses discovered during IOT&E. Because of the scope of this system, and changes to existing processes, the MHS GENESIS enterprise requires additional subject matter experts for problem resolution, content development, continued training, and other operational assistance. Usability has improved on the System Usability Scale since IOT&E Phase 2, from "unacceptable" to "marginal-low." System availability was 89 percent during the test period. Defense Enrollment Eligibility Reporting System (DEERS) outages accounted for nearly half the of the MHS GENESIS non-availability time. Testing to determine the ability of the MHS GENESIS network infrastructure to sustain the expected number of users at full deployment has not yet been conducted.
- The CVPAs and AA, conducted by JITC and NAVWAR Red Team, showed that MHS GENESIS is not survivable in the complex, cyber-contested environment of a major medical facility. Compared to previous testing, cyber defenders were more effective in detecting NAVWAR Red Team attacks and taking appropriate action to contain the attackers. However, the AA found that 18 of 39 cybersecurity vulnerabilities identified during previous testing remained open, and testing identified 15 new cybersecurity vulnerabilities.

Recommendations

1. The Under Secretary of Defense (Personnel and Readiness) should provide sufficient resources to DHA to support problem resolution, content development, continued training, and other operational assistance during MHS GENESIS deployment and sustainment.
2. The VA should allow DOT&E and JITC to assist with operational testing of early MHS GENESIS deployments at the VA.
3. The Program Office should:
   - Work with DOT&E to plan another FOT&E of MHS GENESIS to evaluate corrective actions and revised training, focused on capabilities shown to be not effective during this FOT&E. The FOT&E should be conducted no later than the implementation of the Block 4 capability upgrade, currently scheduled for January 2021.
   - Continue to fix deficiencies identified in IRs, focusing on Priority 1 and 2 problems, and verify fixes through operational testing.
   - Improve the overall training program, to include Instructor-Led Training and one-on-one training.
   - Improve interoperability, focusing on interface problems that could affect patient safety.
   - Continue to fix known cybersecurity deficiencies.
   - Conduct periodic capacity and latency assessments during future deployments to ensure that the required quality of service to the users is not degraded.

4. The DHA should:
   - Improve communications with the user base by implementing a consistent method of notifying them about changes to the system.
   - Maintain access to the AHLTA at sites operating with MHS GENESIS until resolution of interoperability problems, including data reconciliation, to ensure providers have access to all historical medical record data.

F-35 Joint Strike Fighter (JSF)

Executive Summary

IOT&E Progress

- Summary: As of the end of September 2020, the remaining required IOT&E events are 64 mission trials in the F-35 Joint Simulation Environment (JSE) and two AIM-120 missile trials that were awaiting corrections to deficiencies in the aircraft's mission systems software. Corrections were added to software version 30R04.52 that enabled one AIM-120 trial to be completed in late October, but the other trial requires additional corrections to deficiencies.
- JSE: The JSE is a man-in-the-loop, F-35 software-in-the-loop mission simulator that will be used to conduct IOT&E test missions with modern threat types and densities in scenarios that are not able to be replicated on the open-air ranges. The IOT&E plan requires 64 mission trials in the JSE against modern, fielded, near-peer adversary threats in realistic densities.
  - Despite clear requirements and focused efforts by the F-35 Joint Program Office (JPO) and JSE development teams, the JSE will not be ready for IOT&E events in CY20, which is over 3 years later than planned.
  - The ongoing IOT&E JSE verification, validation, and accreditation (VV&A) processes must be completed, along with consistent independent schedule reviews, to finish the JSE and IOT&E, now expected to occur in mid-to-late CY21.
  - The decision to move F-35 JPO management of the JSE into the F-35 JPO Training Systems and Simulation Program Management Office is concerning in that the JSE must still have adequate fidelity to be accredited for scored operational test (OT) trials to complete IOT&E.
  - The JSE is required to complete IOT&E as it is the only venue, other than actual combat against near-peer adversaries, to adequately evaluate the F-35.
- Weapons Trials: Having completed the majority of the weapons trials previously, the Joint Strike Fighter (JSF) Operational Test Team (JOTT) worked to complete the remaining events in FY20. The JOTT was able to complete one AIM-120 missile trial and two Paveway IV bomb trials in July 2020. These test trials were designed to evaluate weapon performance in a GPS-contested environment. The JOTT completed one of two remaining IOT&E AIM-120 trials in October. The remaining AIM-120 trial is expected to occur in early CY21 with the version of 30R06 that will be fielded. An additional weapons test trial, originally included in the IOT&E test plan, is deferred to post-IOT&E testing.
- Electronic Attack (EA) Trials: DOT&E approved the start of the EA mission trials at Point Mugu Sea Range (PMSR), California, on July 10, 2020. The JOTT completed the four EA trials later that same month.

Block 4 / Continuous Capability Development and Delivery (C2D2) Progress

- The current development process used by the F-35 JPO and Lockheed Martin, that is supposed to provide new capabilities and updates in 6-month increments, is not working. It is causing significant delays to planned schedules and results in poor software quality containing deficiencies.
- The current C2D2 process has not been able to keep pace with the scheduled additions of new increments of capability. Software changes, intended to introduce new capabilities or fix deficiencies, often introduced stability problems and/or adversely affected other functionality. Due to these inefficiencies, along with a large amount of planned new capabilities, DOT&E considers the program's current Revision 15 master schedule to be high risk.
- The JSF program continues to carry a large number of deficiencies, many of which were identified prior to the completion of System Development and Demonstration (SDD) in April 2018. As of October 2, 2020, the program had 871 open deficiencies, 10 of which were designated Category 1. Although initial development in Block 4 has focused on addressing deficiencies while developing some new capabilities, the overall number of open deficiencies has not changed significantly since the completion of SDD due to ongoing discoveries of new problems.
- The program continues to plan for a greater dependence on modeling and simulation (M&S) in Block 4 than was used during SDD and, as such, must establish internal processes to aid in the development and enhancement of the associated M&S capabilities. However, as of the writing of this report,

very little change in the laboratories and simulation venues has occurred or is currently programmed.
- Testing the planned new Technical Refresh (TR)-3 avionics configuration will further strain the program's limited test infrastructure (i.e., aircraft and labs). Software sustainment and capability modifications of both TR-3 and legacy TR-2-based aircraft will continue to be a concern, including the high cost and multiple hardware configurations of fielded aircraft, many of which will require updates and upgrades for years to come. The use of the F-35 JSE will continue to be a critical part of an adequate evaluation of F-35 Block 4 combat capabilities. As such, the F-35 JPO must continue work to align F-35 JSE VV&A with the C2D2 process to ensure that the JSE is able to be accredited for test and used for training with every 6-month release. Currently, during detailed test planning for each 6-month drop of capability, there is little activity to align collection of open air flight test data for use in VV&A of Block 4 capabilities in the JSE.
- As proven during IOT&E, adequate evaluation of Block 4 capabilities will require the continued use of Open Air Battle Shaping (OABS) instrumentation and Radar Signal Emulators (RSE).
- OT aircraft will be needed to support both developmental and operational test requirements. Modifications to these aircraft must be funded, scheduled, and completed just after developmental test (DT) aircraft modifications to enable integrated DT/OT, DT assist, and relevant mission-level testing of future capabilities. However, as of this report modifications to OT aircraft are not funded, nor on contract to be able to support DT, let alone accomplish required OT mission-level evaluation.

Mission Data Load (MDL) Development and Testing
- Although the program has initiatives in progress, the U.S. Reprogramming Laboratory (USRL) still lacks adequate equipment to fully test and optimize MDLs under realistic stressing conditions to ensure performance against current and future threats. In spite of this fact, the F-35 JPO recently reduced funding to the USRL that cut flight test support of new MDLs, thus limiting dedicated MDL testing to inadequate laboratory venues only.
- Significant additional investments, well beyond the recent incremental upgrades to the signal generator channels and reprogramming tools, are required now for the USRL to support F-35 Block 4 MDL development. At the time of this report, the program has budgeted for some of these hardware and software tools, but they are already late to need for supporting fielded aircraft and Block 4 development.

Availability, Reliability, and Maintainability
- Although the fleet-wide trend in aircraft availability showed modest improvement in 2019 and early 2020, the average fleet-wide monthly availability rate for only the U.S. aircraft, for the 12 months ending in September 2020, is below the target value of 65 percent.
- Individual deployed units met or exceeded the 80-percent Mission Capable (MC) and 70-percent Fully Mission Capable (FMC) rate goals intermittently, but were not able to meet these goals on a sustained basis.
- Each variant is meeting at least one target value needed to reach requirements at maturity of the three reliability metrics defined in the JSF Operational Requirements Document (ORD). None of the variants are meeting target values for the two maintainability measures defined in the ORD.

Autonomic Logistics Information System (ALIS) and Operational Data Integrity Network (ODIN)
- Although the program released several versions of ALIS 3.5 in CY20, the program has not been able to generate and field quarterly updates as planned. While some delays are attributable to restrictions imposed by the coronavirus (COVID-19) pandemic, others are related to improving overall software quality and stability. Additionally, the program sought efficiencies in deploying the updates when practical, such as combining updates that required rebuilding Portable Maintenance Aids. Each delay in a quarterly release has had a waterfall effect on those following it. Users have reported improvements to ALIS stability and usability with the fielding of ALIS 3.5.
- Although the program continues data, software, and hardware development for ODIN, an overarching test strategy that includes government and contractor laboratory facilities has yet to be provided. The schedules for ODIN Initial Operational Capability (IOC) and Final Operational Capability (FOC) remain high risk.

Live Fire Test and Evaluation (LFT&E)
- DOT&E completed the evaluation of the F-35 vulnerability to kinetic threats. Testing and evaluation of the F-35 survivability against chemical, biological, radiological, and nuclear threats is nearing completion:
  - Chemical and biological decontamination of the Generation (Gen) III and Gen III Lite Helmet-Mounted Display System (HMDS) was not demonstrated, which must occur as part of Block 4 testing.
  - In FY20, the Naval Air Warfare Center Aircraft Division at Naval Air Station Patuxent River (Pax River), Maryland, completed system-level testing of the F-35B variant to evaluate tolerance to electromagnetic pulse (EMP) threats.
- The evaluation of the F-35 gun lethality against operationally relevant targets is ongoing and is expected to be completed in FY21.
- F-35 vulnerability and lethality evaluation details will be provided in the combined IOT&E and LFT&E report to be published in support of the Full-Rate Production decision.

Cybersecurity Operational Testing
- While some cybersecurity-related system discrepancies have been resolved, cybersecurity testing during IOT&E continued to demonstrate that some vulnerabilities identified during earlier testing periods have not been remedied. More testing is needed to assess cybersecurity of logistics support systems and the air vehicle (AV) itself.

System

- The F-35 JSF program is a tri-Service, multinational, single seat, single-engine family of strike fighter aircraft consisting of three variants:
  - F-35A Conventional Take-Off and Landing
  - F-35B Short Take-Off/Vertical-Landing
  - F-35C Aircraft Carrier Variant
- Per the JSF ORD for SDD, the F-35 is designed to operate and survive in the IOC and IOC-plus-10-years threat environment (out to 2025, based on the first IOC declaration by the U.S. Marine Corps in 2015). It is also designed to have improved lethality in this environment compared to legacy multi-role aircraft.
- Using an active electronically scanned array (AESA) radar and other sensors, the F-35, with Block 4, 30 Series software, currently employs precision-guided weapons (e.g., GBU-12 Laser-Guided Bomb, GBU-49 Dual GPS/Laser-Guided Bomb, GPS-Guided Joint Direct Attack Munition (JDAM), GPS-Guided Small Diameter Bomb I (SDB I), and Navy GPS-Guided Joint Stand-Off Weapon)); air-to-air missiles (e.g., AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) and AIM-9X infrared guided, air-to-air missile); and a 25-mm gun.
- The F-35 Modernization Block 4 Capability Development Document addresses required capabilities and associated capability gaps that drive incremental improvements in capability from 2018 and beyond. Block 4 modernization will add new hardware, software, and weapons, including SDB II, AIM-9X Block II, B-61, Advanced Anti-Radiation Guided Missile-Extended Range (AARGM-ER), and several international partner weapons.

Mission

Combatant Commanders will employ units equipped with F-35 aircraft in joint operations to attack fixed and mobile land targets, surface combatants at sea, and air threats, including advanced aircraft and cruise missiles, during day or night, in all weather conditions and in heavily defended areas.

Major Contractor

Lockheed Martin, Aeronautics Company – Fort Worth, Texas

Activity

IOT&E Progress

Activity

- The JOTT continued testing throughout FY20, in accordance with the DOT&E-approved F-35 IOT&E test plan, while preparing to execute the remaining IOT&E events and analyzing test data to draft their report.
- The program continued to make slow progress in preparing the JSE for IOT&E test trials. See subsequent section on the JSE on page 25 for further details.
- In August 2019, the program began moving 13 of the 16 total RSEs and supporting equipment from the Nevada Test and Training Range (NTTR) to the PMSR in preparation for the remaining four 4 EA open-air trials. All 13 RSEs completed movement to the west coast sites and were upgraded with the latest software in April 2020 to support final integration and testing.
- After several check-out missions that demonstrated successful integration of the RSEs at PMSR, along with overall test readiness and adequacy, DOT&E approved the start of the four EA test missions at PMSR on July 10, 2020. The EA mission trials, which were completed within the month of July, evaluated the F-35A and F-35C in the role of suppression/destruction of enemy air defenses versus modern fielded threats.
- The JOTT completed one AIM-120 missile trial and two Paveway IV bomb trials in July 2020. These test trials were designed to evaluate weapon performance in a GPS-contested environment. The JOTT completed one of two remaining IOT&E AIM-120 trials in October. The remaining AIM-120 trial is expected to occur in early CY21 with the version of 30R06 that will be fielded. An additional weapons test trial, originally included in the IOT&E test plan, is deferred to post-IOT&E testing.
- The JOTT completed the Low Observable Stability Over Time (LOSOT) testing required in the IOT&E test plan. The final aircraft to complete LOSOT testing during IOT&E was a U.K. F-35B OT aircraft, designated BK-4, which completed the testing in February 2020.

Assessment

- The JSE is required to complete 64 mission trials against modern, fielded, near-peer adversary threats in realistic densities. The JSE is the only venue available, other than actual combat against near-peer adversaries, to adequately evaluate the F-35 due to inherent limitations associated with open-air testing. The delays in having the JSE ready for formal test events will likely slip completion of IOT&E into mid-to-late CY21.
- All results of the F-35 IOT&E, including the weapons trials, will be included in the DOT&E combined IOT&E and LFT&E report, which will inform the Full-Rate Production decision.

Block 4 / C2D2 Progress

Activity: C2D2

- Block 4 is the overarching development program initiated at the end of SDD, which completed in April 2018. Since that time, the F-35 JPO and Lockheed Martin have continued to address software deficiencies while attemping to add new capabilities via the C2D2 process. Table 1 associates program development phases with major avionics architecture, capabilities and software nomenclature, and key operational test events.

TABLE 1. LINKAGE OF DEVELOPMENT PHASE WITH HARDWARE, BLOCK DESIGNATION, MISSION SYSTEMS SOFTWARE, AND OPERATIONAL TESTING

F-35 DEVELOPMENT PHASE	MAJOR AVIONICS HARDWARE	CAPABILITIES	MISSION SYSTEMS SOFTWARE	OPERATIONAL TESTING*
SDD	TR-1	Block 2B	Block 2B Software	• Marine Corps Fielding Reports and F-35B IOC • Service and JOTT test events • Formal OUE canceled
	TR-2	Block 3i	Block 3i Software	• Air Force Fielding Reports and F-35A IOC • Service and JOTT test events
		Block 3F	Block 3F/ 3FR6**	**Pre-IOT&E Increment 1 (Jan - Feb 2018) Cold Weather Deployment.** For-score testing to evaluate the suitability of the F-35 air system and alert launch timelines in the extreme cold weather environment.
			Block 3F/30R00***	• Navy Service Fielding Reports • **Pre-IOT&E Increment 2** (Starting Mar 2018) For-score testing of limited two-ship mission scenarios, F-35A deployment, F-35C deployment to a carrier, and weapons delivery events
C2D2		Block 4, 30 Series	30R02.04	**Formal IOT&E** (Dec 2018 - Sep 2019)
			30R04.52	**Formal IOT&E Electronic Attack trials** (Jul 2020)
			30R06.0X	Software fix needed for **IOT&E weapons event**
			30R06+	Dedicated Follow-on Operational Test for each planned field release of software.
	TR-3	Block 4, 40 Series	40R0X	Formal Operational Test with new hardware configuration and Dedicated Operational Test for each software release of capability.

Notes:
* For-score IOT&E events are highlighted in bold.
** The final planned version of Block 3F software was 3FR6.
*** The program changed software nomenclature for the initial increments of Block 4 from "3F" used during SDD to "30RXX" for development and "30PXX" for fielding software. The 30 series of software is compatible with the Block 3F aircraft hardware configuration and is being used to address deficiencies and add some Service-prioritized capabilities.

C2D2 – Continuous Capability Development and Delivery; IOC – Initial Operational Capability; JOTT – JSF Operational Test Team; OUE – Operational Utility Evaluation; SDD – System Design and Development; TR-X – Technical Refresh [version#], referring to the suite of core avionics processors

- F-35 Block 4 continues to be on OT&E oversight. DOT&E reviews the content of each Block 4, 30 and 40 series increments, works with the U.S. Operational Test Team (UOTT) and F-35 JPO, and conducts both integrated developmental test/operational test (IDT/OT) and dedicated OT on each increment.
- The C2D2 process is designed to deliver a "Minimum Viable Product" (MVP) increment of software to the Services every 6 months. The 6-month cycle includes an aggressive IDT/OT period, followed by an integrated test team assessment and production recommendation from both DT and OT within 7 days after flight test completion. This process is followed by delivery of any required updates to mission planning software, mission data, ALIS, joint technical data, flight series data, training simulators, and other support capabilities that were still in development and not tested during the 6-month test window. The operational flight program software and support products are then bundled

together into the MVP (planned to be within 6 months after completion of IDT/OT, but updates to training simulators and mission data usually take longer), and delivered to the Services. As a result, the final MVP configurations receive minimal, if any, testing prior to fielding, and significant problems are being discovered during OT and in the field.
- DOT&E requires adequate testing of the full capability of the MVP prior to delivery to the warfighter, but this testing is constrained by the aggressive F-35 JPO delivery schedule and has not been adequately accomplished to date. Going forward, DOT&E will continue working with both the UOTT and F-35 JPO to accomplish dedicated OT on every increment using the final MVP.
- Since the start of the Block 4 C2D2 process over 2 years ago, the program has added the Automatic Ground Collision Avoidance System, which is a priority capability from the Services; interim Full Motion Video, which is a priority capability to the U.S. Marine Corps; some radar updates; and additional weapons capability with the GBU-49 Enhanced Paveway II 500-pound class dual-mode bomb. However, other planned capabilities have slipped to later increments.

Activity: Block 4, 30 Series
- The initial set of Block 4, 30 Series software releases, represented by 30RXX (for test software versions) and 30PXX (for software going to the field), are compatible with aircraft in the TR-2 avionics hardware configuration. These releases are being used to address deficiencies and add some Service-prioritized capabilities.
- During FY20, the program developed and tested multiple versions of 30 Series software, with the plan to field three releases – 30P04.012 in January 2020, 30P04.5 in April 2020, and 30P05 in October 2020.

Activity: Block 4, 40 Series
- Block 4, 40 Series development, which will include the new TR-3 avionics hardware configuration and 40RXX or 40PXX software, is scheduled to begin developmental testing in late CY21 and deliver Lot 15 production aircraft starting in CY23. The Block 4, 40 Series continues to use the C2D2 process to integrate the remaining Decision Memorandum (DM) 90 capabilities and Service-unique priority requirements.
- Block 4 Test and Evaluation Master Plan (TEMP)
  - The program completed coordination on the overarching Block 4 TEMP and Increment 1 Annexes (both unclassified and classified) for software releases 30R03 through 30R06. DOT&E approved the TEMP and Increment 1 Annexes on May 18, 2020.
  - The program is coordinating the Increment 2 Annexes of the TEMP as of the time of this report. These annexes will cover the remaining 30RXX software versions (currently planned as 30R07, 30R08, 30R09) and the first two 40RXX software versions (40R01 and 41R01).

Assessment
- The current development process used by the F-35 JPO and Lockheed Martin, which is supposed to provide new capabilities and updates in 6-month increments, is resulting in significant delays, deferrals of planned capabilities, and poor software quality containing deficiencies. For these reasons, the 6-month development and delivery timeline for the C2D2 process has not worked and remains high risk.
- 30R04 software development took longer and required more software increments than planned. Deficiencies continued to be discovered after development and fielding, both during IOT&E and in the field.
  - The program planned for four DT software builds (30R04.00, 01, 02, 03), but needed 12 (30R04.00, 01, 011, 012, 02, 021, 03, 031, 015, 4.5, 4.51, 4.52) to produce a final 30P04 version that was fielded.
  - The time from first DT flight to field release was approximately 13 months (May 2019 to July 2020) vice the 6 months planned.
  - After the first 6 months and four builds of testing 30R04, the program fielded version 30P04.012. However, combat units found multiple software issues in 30P04.012. Due to these and other issues, the program developed a new software version, 30R04.5.
  - The program added fixes to 19 deficiencies and 37 Software Product Anomaly Reports into 30R04.5.
  - Although the Services planned to field 30R04.5 software in March 2020, continued discoveries of deficiencies and need for fixes delayed fielding until July 2020 with 30R04.52.
  - After fielding of 30P04.52, operational test units continued testing the software and discovered two Category 1 and six additional deficiencies during OT.
- 30R05 software development also took longer and required more software increments than planned.
  - The program planned for four DT software builds (30R05.00, 01, 02, 03), but has produced seven to date (30R05.00, 01, 02, 03, 04, 041, 042).
  - As of October 2020, DT flight testing continues after 11 months (after starting in November 2019), with plans to continue through mid-November 2020.
  - Due to significant unresolved deficiencies and the need to continue development of the next iteration of software (30R06.XX series), the program and Services determined that 30P05 will not be released to the field, which is a deviation from the planned delivery schedule.
  - The delays in development and testing of 30R04 and 30R05 have also caused the integration, testing, and fielding of SDB II and AIM-9X Block II (among other capabilities) to slip from 30R06 to later software versions.
- The program continues to carry a large number of deficiencies, many of which were identified prior to the completion of SDD. As of October 2, 2020, the program had 871 open deficiencies, 10 of which were designated Category 1. Although initial development work in Block 4 has focused on addressing deficiencies while developing some capabilities, the overall number of open deficiencies has not changed significantly since the completion of SDD

in April 2018, at which time the program had 941 open deficiencies, 102 of which were Category 1. This is due to ongoing problems with initial software quality and limited lab and flight test capacity, resulting in a high rate of problem discoveries in OT and the field.

- Although the program continues to plan for a greater dependence on M&S in Block 4 development than was used during SDD, including expanding the use of the JSE for contract specification verification, very little has been done to upgrade the laboratories and simulation venues.
  - Adequate funding to develop and sustain robust laboratory and simulation environments, along with adequate VV&A plans that include the use of data from representative open-air missions, must be planned and programmed so that accredited M&S capabilities are ready to support system development and OT of future increments. Adequate M&S capabilities are not currently planned, nor fully funded, as part of the overall Block 4 development processes.
  - Plans to rely heavily upon M&S (to include a "digital twin" high-fidelity F-35 M&S capability) are neither funded nor in development for use in delivery of future increments. Other programs that presuppose the use of digital twin and M&S to reduce cost and development cycle times should reference initial F-35 program plans and associated lessons learned.
- The cost of software sustainment continues to be a concern. Sustaining multiple hardware configurations of fielded aircraft, while managing developmental and operational test fleets with updated hardware to support the production of new lot aircraft, will continue to strain limited Service budgets.
- DOT&E cited concerns with the overall schedule of development, testing, and fielding of Block 4 capabilities, along with the supporting test infrastructure and resources in the Block 4 TEMP approval memo. The Services and F-35 JPO OT representatives developed a tail-by-tail accounting of OT aircraft, and identified critical modifications to OT aircraft, instrumentation, and other test infrastructure requirements (i.e., USRL, Online Knowledge Management, and JSE hardware upgrades). However, these requirements are not fully funded, programmed, or scheduled for completion by the F-35 JPO in time to support the DT, integrated DT/OT, and dedicated OT periods in the current C2D2 schedule. Additionally, DOT&E identified six requirements that must be addressed for approval of the Increment 2 Annexes:
  - The program must fully fund, develop, and update the detailed plan to modify all OT aircraft with the capabilities, life limit, and instrumentation, including OABS requirements necessary to accomplish OT events in support of the relevant program delivery schedules.
  - A 30-day demonstration of flight operations without ALIS connectivity must be scheduled to be completed by mid-CY21.
  - Collaborative government/contractor cybersecurity testing of the contractor-based supply chain must be scheduled for completion by mid-CY21.
  - The program must align the components of the F-35 air system delivery framework for each increment of capability to allow enough time for adequate testing of the fully representative system that is planned to be fielded, including mission planning, operational mission data, Joint Technical Data and support systems, prior to release to the warfighter.
  - The Scope and Prioritization of Cyber Test Resources for Evaluation process for Block 4 cyber test prioritization must be defined and included in TEMP Increment 2 documentation.
  - The program must conduct an OT Readiness Review for dedicated OT of Block 4 capabilities, which is estimated to begin in late CY20, based on the associated Air System Playbook plan.
- Adequate operational testing will require mission-level evaluations of Block 4 capabilities. These evaluations will require the continued use of OABS instrumentation, RSEs, and the JSE.
  - As proven during F-35 IOT&E testing, the OABS capability is essential to accurately evaluate complex mission trials. DOT&E coordinated the program management function and funding for OABS to reside with the USD(R&E) Test Resource Management Center (TRMC).
    - The F-15C/D/E, F-16 Block 30, F/A-18E/F, EA-18G, and F-22 also have OABS capability, several of which have supported F-35 OT.
    - Going forward, operational testing of the F-22 Release 1 capability, F-15EX and F-16 Block 40/50 upgrades, along with the need to leverage combat air forces and fleet fighter aircraft as a resource for both blue support and adversary air, will continue to require use of OABS in each of the aforementioned aircraft.
  - The RSEs emulate modern air defense radars that are otherwise not available to support testing. Upgrades to, and reprogramming of, the RSEs must continue to be supported by the program. The Service range program managers in coordination with the U.S. Operational Test Team (UOTT) and DOT&E should fully fund new RSEs, as well as upgrades to the RSEs and OABS systems, to meet adequate test requirements for each C2D2 release of capability.
  - The use of the F-35 JSE will continue to be a critical part of an adequate evaluation of F-35 Block 4 combat capabilities. The government JSE team, composed of participants of the F-35 JPO and of Naval Air Systems Command, remains responsible for development and delivery of the F-35 JSE for developmental and operational testing. Use of the JSE for adequate testing of near-term Block 4 capabilities is planned for the 30R09 and each 6-month release thereafter.

Joint Simulation Environment (JSE)

Activity

- Originally slated to be operational by the end of CY17 to support IOT&E spin-up and testing, the JSE encountered significant contractual and developmental delays and is not expected to be ready for IOT&E trials until mid-to-late CY21.
- The JSE physical facilities (i.e., cockpits, visuals, and buildings) and synthetic environment (i.e., terrain, threat, and target digital models) are present; however, full integration and tuning of the F-35, along with other threat and weapon models, are not yet complete.
- The JSE team is preparing to host formal events leading up to IOT&E trials. During those events, the JOTT will man and operate the JSE as they plan for scored trials to assess their scenarios and processes, train test conductors and threat operators, and ensure data integrity in preparation for IOT&E. Those formal events, originally planned to begin in May 2020, have slipped multiple times into CY21 due to continued integration problems and COVID-19 impacts.
- Due to these problems, the F-35 JPO is rebaselining the JSE schedule to account for the delays and incorporate an additional set of full system tests to ensure readiness for the formal events.

Assessment

- In spite of clear requirements for an F-35 simulation to complete IOT&E, the program continued to struggle throughout most of CY20 to complete JSE development and required preparations for test trials in CY20, already 3 years later than originally planned. Completion of IOT&E and the report will occur following successful completion of the required 64 IOT&E trials in the JSE, now expected to occur in mid-to-late CY21.
- The government-led JSE team made progress in early CY20 completing integration of the F-35 In-A-Box model into the high-fidelity threat environment, both of which are likely to meet requirements for IOT&E. However, development and integration testing intended to discover deficiencies in test execution processes were hampered by COVID-19 restrictions and continued problem discoveries.
- During assessments in mid-CY20, the JOTT noted significant progress in simulator stability, simulator operations, data collection processes, and facilities. However, problems involving the interaction of several models persisted and were difficult to solve with disparate teams unable to travel. By fall 2020, reduced travel restrictions allowed more integrated approaches and discrepancies were being addressed at a good rate. However, continued problem discoveries showed the JSE was still not maturing fast enough to meet a CY20 test-for-score timeline.
- In CY21, after completing integration, VV&A, and the for-score IOT&E trials, the JSE will be an invaluable resource for high-end training, tactics development, early pilot-vehicle interface developmental testing, and operational testing of Block 4 capabilities. To ensure it is adequate to support operational testing in Block 4, the JSE V&V processes must be continued.
- The OABS, RSEs, and other open-air test capabilities must be used to gather accurate flight test data that will be used for VV&A of the JSE. Without the open-air test data to validate the JSE, it may not be an accurate representation of installed F-35 performance and thus could provide misleading results to acquisition decision-makers, the warfighter, and Congress.
- The JSE team and other stakeholders must continue work to align F-35 JSE VV&A with the C2D2 process to ensure that the JSE is able to be accredited for test and used for training with every 6-month release. Currently, during detailed test planning for each 6-month drop of capability, there is little activity to align collection of open air flight test data for use in VV&A of Block 4 capabilities in the JSE.
- The decision to move F-35 JPO management of the JSE into the F-35 JPO Training Systems and Simulation Program Management Office is concerning in that the JSE must still have adequate fidelity to be accredited for scored OT trials to complete IOT&E.

Mission Data Load (MDL) Development and Testing

Activity

- F-35 effectiveness relies on the MDL, which is a compilation of the mission data files needed for operation of the sensors and other mission systems. The MDL works in conjunction with the avionics software and hardware to drive sensor search behaviors and provide target identification parameters. This enables the F-35 avionics to identify, correlate, and respond to sensor detections, such as threat and friendly radar signals.
- The USRL at Eglin AFB, Florida, creates, tests, and verifies operational MDLs – one for OT and training, and one for each potential major geographic area of operation, called an area of responsibility (AOR). The OT and fielded aircraft use the applicable USRL-generated MDLs for each AOR.
- Testing of the USRL MDLs is an operational test activity on DOT&E oversight. During SDD, test plans included laboratory as well as flight testing of the MDL on OT aircraft. The F-35 JPO recently reduced or eliminated funding support for flight testing of new MDLs, essentially reducing testing to inadequate laboratory venues only.
- As a part of their organizational restructuring, the F-35 JPO created a Combat Data Systems Program Management Office to address fiscal and organizational challenges in developing mission data for all U.S., partner, and foreign military sales countries, particularly under the rapid, 6-month cycle of product development in Block 4.

Assessment

- Because MDLs are software components essential to F-35 mission capability, the DOD must have a reprogramming lab that is capable of rapidly creating, testing, and optimizing MDLs, as well as verifying their functionality under stressing conditions representative of real-world scenarios.

- The USRL still lacks adequate equipment to be able to test and optimize MDLs under conditions stressing enough to ensure adequate performance against current and future threats in near-peer combat environments.
  - As DOT&E has reported in the past, the USRL lacks a sufficient number of high-fidelity radio frequency signal generator channels, which are used to stimulate the F-35 electronic warfare (EW) system and the radar with simulated threat radar signals. While some improvement has been made, additional improvements, above and beyond those currently planned, are required. Also, some of the USRL equipment lacks the ability to accurately pass the simulated signals to the F-35 sensors in a way that replicates open-air performance.
  - In 2019, both USRL mission data test lines were upgraded from three to eight high-fidelity signal generator channels. Eight high-fidelity channels per line represent a substantial improvement, but are still far short of the 16-20 recommended in the F-35 JPO's own 2014 gap analysis.
- The reprogramming lab must also be able to rapidly modify existing MDLs because frequent changes in threat capabilities, based on new intelligence data, require updated MDLs.
  - Reprogramming tools continue to be unique to specific software builds and are cumbersome to use.
  - This situation improved some in 2018 with the delivery of a new Mission Data File Generation tool set from the contractor, but additional improvements are still necessary for the tools to fully meet expectations.
- Significant additional investments are required now for the USRL to support F-35 Block 4 MDL development. The current lab infrastructure is not keeping pace with the planned 6-month delivery of aircraft software and the large number of operational MDLs for different geographic regions. Based on future Block 4 capabilities, the USRL will only continue to fall further behind program deliveries.
  - To provide mission data for the aircraft with new avionics hardware in the Block 4 configuration, the new avionics hardware is also required in the USRL. After the development program enters the Block 4, 40 Series phase, the previously fielded F-35 Block 4, 30 Series configurations will also continue to need support indefinitely (i.e., until a specific configuration is modified or retired). These fielded configurations include aircraft with TR-2 processors, 30 Series software, and the original EW system; TR-2 aircraft with new EW equipment called the Digital Channelized Receiver Techniques Generator and Tuner Insertion Program in Lot 11 and later aircraft; and possibly an additional TR-2 configuration with new display processors. Adequate plans for supporting all these configurations are not in place.
  - In order to support the planned Block 4, 40 Series capability development timeline, the Block 4 hardware upgrades for the USRL should have already been on contract. However, as of this report, the requirements for the Block 4 software integration lab and USRL have yet to be fully defined.

Static Structural and Durability Testing

Activity

- Teardown inspections of the F-35A full scale durability test article (AJ-1) completed in July 2019. The F-35A Durability and Damage Tolerance (DADT) report was released in August 2020.
- Teardown inspections of the original F-35B full scale durability test article (BH-1) completed in October 2018. The program canceled third lifetime testing of BH-1 due to the significant amount of discoveries, modifications, and repairs to bulkheads and other structures that caused the F-35B test article to no longer be representative of the wing-carry-through structure in production aircraft. Release of the DADT report on BH-1 was expected in November 2020, but has been delayed to 2021. The program secured funding and contracted to procure another F-35B ground test article, designated BH-2, which will have a redesigned wing-carry-through structure that is production-representative of Lot 9 and later F-35B aircraft. Contract actions for BH-2 were completed in November 2019 and testing of the first lifetime is scheduled to begin in 1QFY24. The BH-2 ground test article will come from Lot 15 production.
- Disassembly and teardown of the F-35C durability test article (CJ-1) completed in November 2019. The program stopped testing during the third lifetime testing in April 2018, following the discovery of more cracking in the Fuselage Station (FS) 518 Fairing Support Frame. The cracking was discovered near the end of the second lifetime and required repairs before additional testing could proceed. After estimating the cost and time to repair or replace the FS 518 Fairing Support Frame, coupled with other structural parts (i.e., fuel floor segment, bulkheads FS 450, FS 496, FS 556, and front spar repair) that had existing damage, the program determined that the third lifetime testing would be discontinued. Release of the DADT report on CJ-1 was expected in November 2020, but has been delayed to 2021.

Assessment

- For all F-35 variants, structural and durability testing during SDD led to significant discoveries requiring repairs and modifications to production designs, some as late as Lot 12 aircraft, and retrofits to fielded aircraft.
- Based on durability test data, there are several life-limited parts on early production F-35 aircraft that require mitigation. In order to mitigate these durability and damage tolerance shortfalls, the program plans to make modifications to these early production aircraft, including the use of laser shock peening to increase fatigue life for specific airframe parts on the F-35B (i.e., bulkheads). The F-35 JPO will also continue to use individual aircraft tracking of actual usage to help the Services project changes in timing for

required repairs and modifications, and to aid in fleet life management.

- Although the program planned for a third lifetime of testing to accumulate data for life extension, if needed, the program has no plan to procure another F-35C ground test article.

Availability, Reliability, and Maintainability

F-35 Availability

Activity

- As of the end of September 2020, 563 aircraft have been produced for the U.S. Services, international partners, and foreign military sales. These aircraft are in addition to the 13 aircraft dedicated to developmental testing.
- The following assessment of fleet availability, reliability, and maintainability is based on sets of data collected from the operational, test, and training units and provided by the F-35 JPO. The assessment of aircraft availability is based on data provided through the end of September 2020. Reliability and maintainability (R&M) assessments in this report are based on data covering the 12-month period ending April 30, 2020. Data for R&M include the records of all maintenance activity and undergo an adjudication process by the government and contractor teams, a process which creates a lag in publishing those data. The differences in data sources and processes create an apparent disparity in dates for the analyses in this report.
- In March 2020, the program set a baseline Mission Capable (MC) rate goal of 70 percent and a Full Mission Capable (FMC) rate goal of 40 percent for the whole fleet to attain by September 2020. Additionally, the program set elevated MC and FMC goals for units that were training to deploy of 75 percent and 60 percent, respectively, and even higher MC and FMC goals of 80 percent and 70 percent, respectively, for units that were in a deployed status. The MC rate represents the percentage of unit-assigned aircraft capable of performing at least one defined mission, excluding those aircraft in depot status or undergoing major repairs. MC aircraft are either FMC, meaning they can perform all missions assigned to the unit, or Partial Mission Capable (PMC), meaning they can fly at least one, but not all, missions. The MC rate is different than the availability rate, which is the number of aircraft capable of performing at least one mission divided by all aircraft assigned, including aircraft in depot status or undergoing major repairs.

Assessment

- The operational suitability of the F-35 fleet remains at a level below Service expectations, but has shown improvement in several metrics. After several years of remaining stable or only moving within narrow bands, several key suitability metrics began to show signs of slow, but continuous, improvement in CY19, a trend that continued into early CY20, but then became more ambiguous and variable by mid-year.
- Aircraft availability is determined by measuring the percentage of time individual aircraft are in an "available" status, aggregated monthly over a reporting period.
  - The historic program-set availability goal is 65 percent; the following fleet-wide availability discussion uses data from the 12-month period ending September 2020.
  - For this report, DOT&E is reporting availability rates only for the U.S. fleet, vice including international partner and foreign military sales aircraft, as was done in previous reports.
- The average fleet-wide monthly availability rate for only the U.S. aircraft (includes all aircraft categories – those designated for combat, training, and operational test and tactics development), for the 12 months ending September 2020, is below the target value of 65 percent. The DOT&E assessment of the trend shows evidence of slight overall improvement in U.S. fleet-wide availability from 2019 through at least early 2020, followed by an extended period of no clearly discernible trend. Monthly availability surpassed the target value of 65 percent for the first time ever in 2020, and peaked in April at an all-time program high, but it has been as much as 9 percent lower than the all time high since then.
- The combat coded fleet of aircraft are assigned to units that can deploy for combat operations; the training fleet for new F-35 pilot accession; and the test fleet for operational testing and tactics development. The proportion of the fleet that is combat coded has risen steadily over time, and was a little less than half of the whole U.S. fleet over the period considered. Consistent with prior annual reports, the combat coded fleet, which has the newest aircraft on average, demonstrated the highest availability and achieved the 65 percent target for monthly average availability for the 12 months ending in September 2020.
- Aircraft that are not available are designated in one of three status categories: Not Mission Capable for Maintenance (NMC-M), Depot (in the depot for modifications or repairs beyond the capability of unit level squadrons), and Not Mission Capable for Supply (NMC-S).
  - The average monthly NMC-M and Depot rates were relatively stable, with little variability, and near program targets. Both rates were slightly worse than program targets, however, with the NMC-M rate slightly farther off the goal than the Depot rate. Additional focused maintenance system improvements are needed, especially for common processes that are distributed amongst many different NMC-M drivers, such as low observable repairs and adhesive cure times.
  - After significant investment by the program on spare parts, the average monthly NMC-S rate was more variable, but continued to improve until reaching program target levels in September 2020. This improvement was largely responsible for the corresponding improvement in fleet-wide availability. Alternate sources of repair (including organic repair) for current and projected NMC-S drivers are needed to sustain this improvement.
- The average monthly utilization rate can be measured in either flight hours or sorties per aircraft per month. For this report, DOT&E is using flight hours per aircraft per month.

The average utilization rate for the whole fleet overall increased slightly over previous years, but remains below original Service plans. However, this improvement was due entirely to an increase in utilization of the F-35A fleet, and was particularly concentrated within the combat-coded portion of the F-35A fleet.

- Low utilization rates continue to prevent the Services from achieving their full programmed fly rates, which are the basis of flying hour projections and sustainment cost models. For the 12 months ending in September 2020, the average monthly utilization rate for the whole U.S. fleet was 19.6 flight hours per aircraft per month. For the F-35A, it was 20.6 flight hours; the F-35B was 14.6 flight hours; and the F-35C was 23.1 flight hours. This compares to Service plans from 2013, which expected F-35A and F-35C units to execute 25 flight hours per aircraft per month and F-35B units to execute 20 flight hours per aircraft per month to achieve Service goals.

• DOT&E conducted a separate availability analysis of the OT fleet of aircraft, using data from the 20-month period beginning December 2018, when formal IOT&E started, through July 2020. This assessment accounts for the full complement of 23 U.S. and international partner aircraft assigned to the OT fleet at the end of September 2019 (eight F-35A, nine F-35B, and six F-35C).
  - The average monthly availability rate for F-35 OT aircraft was below the planned 80 percent needed for efficient conduct of IOT&E. However, judicious maintenance planning, test range scheduling, and effective mission execution allowed the JOTT to execute trials at a quicker pace than planned for worst-case scenario projections.

• The MC and FMC rates of the whole U.S. fleet followed a similar trend as availability, improving slightly in 2020.
  - Both the combat coded and the OT aircraft, including those used by tactics development, achieved an average monthly MC rate at or surpassing the 70 percent baseline MC rate goal the program set for all units. However, neither the training fleet nor the entire U.S. F-35 fleet as a whole met this goal.
  - The U.S. F-35A variant-specific fleet met the 70 percent MC rate goal, but neither the F-35B nor the F-35C fleets did.
  - Overall, FMC rates still lag MC rates by a large margin, indicating relatively low readiness for the mission sets requiring fully-capable aircraft (i.e., versus near-peer threats).
  - The fleet-specific trends were very similar relative to the program-set 40 percent baseline goal. The combined (i.e., all variants) combat coded and OT fleets (including aircraft dedicated to tactics development), and the F-35A fleet met or surpassed this FMC rate goal. However, the overall fleet, the combined training fleet, and the F-35B and F-35C fleets did not.
  - While all three F-35 variants exhibited MC rates within a relatively tight band, which all increased slowly throughout 2020, the FMC rates between each variant were widely dispersed and diverged in 2020.
  - Almost all FMC growth was concentrated in the F-35A fleet, which exhibited FMC performance far in exceedance of the F-35B and F-35C variants. The F-35B fleet actually saw a decline in its FMC rate over the period, but it still maintained a higher FMC rate than the F-35C, which showed a stagnant trend at a very low rate between 2019 and 2020.

• Individual deployed units met or exceeded the 80 percent MC rate and 70 percent FMC rate goals on occasion, but were not able to meet these goals on a sustained basis.

F-35 Fleet Reliability

Activity

• The F-35 program developed reliability growth projection curves for each variant throughout the development period as a function of accumulated flight hours. These projections compare observed reliability with target numbers to meet the threshold requirement at maturity (200,000 total F-35 fleet flight hours, with a minimum of 50,000 flight hours per variant). In the program’s reliability growth plan, the target flight hour values were set at 75,000 flight hours each for the F-35A and F-35B, and 50,000 flight hours for the F-35C to establish the 200,000 flight hours of fleet maturity. The F-35A fleet reached 75,000 flight hours in July 2018 and had not reached ORD thresholds for reliability and maintainability at the time. DOT&E is continuing to track the following metrics beyond the flight hours required for maturity of the F-35A fleet for reporting purposes. As of April 30, 2020, the date of the most recent set of reliability data available, the fleet and each variant accumulated the following flight hours, with the percentage of the associated hour count at maturity indicated:
  - The complete F-35 fleet accumulated 232,885 flight hours, or 116 percent of its maturity value.
  - The F-35A accumulated 146,452 hours, or 195 percent of its target value in the reliability growth plan.
  - The F-35B accumulated 56,529 hours, or 75 percent of its target value in the reliability growth plan.
  - The F-35C accumulated 29,904 hours, or 60 percent of its target value in the reliability growth plan.

• The program reports reliability metrics for the three most recent months of data. This rolling 3-month window dampens month-to-month variability while providing a short enough period to distinguish current trends.

Assessment

• Aircraft reliability assessments include a variety of metrics, each characterizing a unique aspect of overall weapon system reliability.
  - Mean Flight Hours Between Critical Failure (MFHBCF) includes all failures that render the aircraft unsafe to fly or would prevent the completion of a defined F-35 mission.

- Mean Flight Hours Between Removal (MFHBR) indicates the degree of necessary logistical support and is frequently used in determining associated costs.
- Mean Flight Hours Between Maintenance Event Unscheduled (MFHBME_Unsch) is a reliability metric for evaluating maintenance workload due to unplanned maintenance.
- Mean Flight Hours Between Failure, Design Controllable (MFHBF_DC) includes failures of components due to design flaws under the purview of the contractor.

• Table 2 shows the trend in each reliability metric by comparing values from April 2019 to those of April 2020 and whether the current value is on track to meet the requirement at maturity.

TABLE 2. F-35 RELIABILITY METRICS (UP ARROW REPRESENTS IMPROVING TREND)

Variant	Flight Hours for ORD or JCS Threshold	Assessment as of April 30, 2020												
		Cumulative Flight Hours	MFHBCF (hours)			MFHBR (hours)			MFHBME (hours)			MFHBF_DC (hours)		
			ORD Threshold	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for ORD Threshold	ORD Threshold	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for ORD Threshold	ORD Threshold	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for ORD Threshold	JCS Requirement	Change: Apr 2019 to Apr 2020	Meeting Interim Goal for JCS Threshold
F-35A	75,000	146,452	20	↑	No	6.5	↑	Yes	2.0	↑	Yes	6.0	↑	Yes
F-35B	75,000	56,529	12	↑	Yes	6.0	↑	No	1.5	↑	Yes	4.0	↑	Yes
F-35C	50,000	29,904	14	↑	Yes	6.0	↑	No	1.5	↑	Yes	4.0	↑	Yes

• Between April 2019 and April 2020, all nine of the ORD metrics increased in value, some to a historically unprecedented degree for the program. As a result, in April 2020, six of the nine ORD metrics were at or above their requirement or interim growth goal based on the program's reliability growth plan, whereas in April 2019, none were. Similarly, all three of the JSF Joint Contract Specification metrics increased.

• The cause of these rapid increases in reliability are still under investigation, and likely not due entirely to the proliferation of new, redesigned hardware components throughout the fleet. Preliminary research shows that some of the reliability increases are concentrated almost entirely within certain production lots, which are not necessarily the most recent lots. The lots that exhibited the increased reliability performance also tended to be the lots that made up the bulk of the deployed aircraft over the time period considered. These deployed aircraft flew considerably longer missions during the deployments, and accrued flight hours at a much higher rate than the non-deployed aircraft. This change in usage may partly explain some of the reliability increases. Software changes are also a candidate driver for reliability improvements, but investigations of root causes are currently inconclusive.

Maintainability

Activity

• The program reports maintainability metrics for the three most recent months of data. This rolling 3-month window dampens month-to-month variability while providing a short enough period to distinguish current trends.

Assessment

• The amount of time needed to repair aircraft and return them to flying status has changed little over the past year, and remains higher than the requirement for the system at maturity. The program assesses this time with several measures, including Mean Corrective Maintenance Time for Critical Failures (MCMTCF) and Mean Time To Repair (MTTR) for all unscheduled maintenance. Both measures include "active touch" labor time and cure times for coatings, sealants, paints, etc., but do not include logistics delay times, such as how long it takes to receive shipment of a replacement part.

• Table 3 shows the nominal change in each maintainability metric by comparing values from April 2019 to those of April 2020. While nominally five of six metrics improved, the improvements were minor and longer term trend analyses show no significant improving or worsening trend in maintenance times.

- All mean repair times are longer, some up to more than twice as long, as their original ORD threshold values for maturity, reflecting a heavy maintenance burden on fielded units.
- The F-35 JPO, after analyzing MTTR projections to maturity, acknowledged that the program would not meet the MTTR requirements defined in the ORD. The F-35 JPO sought and gained relief from the original MTTR requirements. The new values are 5.0 hours for both the F-35A and F-35C, and 6.4 hours for the F-35B. This will affect the ability to meet the ORD requirement for Sortie Generation Rate (SGR), a Key Performance Parameter.

TABLE 3. F-35 MAINTAINABILITY METRICS (DOWN ARROW REPRESENTS IMPROVING TREND)								
Variant	Flight Hours for ORD Threshold	Assessment as of April 30, 2020						
		Cumulative Flight Hours	MCMTCF (Hours)			MTTR (Hours)		
			ORD Threshold	Change: Apr 2019 to Mar 2020	Meeting Interim Goal for ORD Threshold	ORD Threshold	Change: Apr 2019 to Mar 2020	Meeting Interim Goal for ORD Threshold
F-35A	75,000	142,094	4.0	↓	No	2.5	↓	No
F-35B	75,000	55,428	4.5	↑	No	3.0	↓	No
F-35C	50,000	29,130	4.0	↓	No	2.5	↓	No

ALIS

Activity

- ALIS activity in 2020 centered on stabilizing ALIS with several releases of ALIS 3.5. The program completed testing during flight operations with ALIS 3.5 in October 2019, but only fielded it at Nellis AFB, Nevada. ALIS 3.5.1 flight operations testing completed in December 2019 and was fielded to four sites in early 2020 before ALIS 3.5.2 completed flight operations testing in January 2020. After that, most sites received ALIS 3.5, 3.5.1, and 3.5.2 simultaneously, with fielding completed in the summer of 2020.
- Content in these updates includes the following.
  - ALIS 3.5 enhancements included the alignment of mission capable status across ALIS applications, correcting deficiencies in time accrual associated with Production Aircraft Inspection Reporting System (PAIRS) processing, and improvements in the Low Observable Health Assessment System.
  - ALIS releases 3.5.1 and 3.5.2 included display improvements so users could more easily view the overall assessment of aircraft status with reduced user workload. This allows maintainers to view Health Reporting Codes (HRCs) and work orders on one screen, see prioritized groupings of HRCs, view the missions available and unavailable for each aircraft depending on its maintenance status. The improvements also provide a direct link between ALIS applications to streamline HRC submission options, allow bulk sign-off of multiple maintenance actions at one time, and loading of multiple weapons stations using a single work order.
- In May 2020, the planned first quarter ALIS update at Edwards AFB, California, was evaluated by the developmental test team, which recommended the program not release it to the fleet due to the presence of a Category 1 deficiency affecting the software data load. Delays in development and flight test, due in part to COVID-19 restrictions, caused the program to delay release of this update until it could be released concurrently with the second quarter update. Additionally, both quarterly updates required rebuilding the Portable Maintenance Aids (PMAs) and the program elected to combine the releases to reduce the administrative burden of rebuilding the PMAs twice. The program originally planned an August 2020 fielding for both (now concurrent) updates.
  - Content in this combined update includes modernized alternate mission equipment (AME) and weapons management, technology upgrades, Internet Explorer 11 on servers, improved end-of-life support for baseline products, security improvements, improved Customer Relations Management validation, user notification of Distribution Tracking Record (DTR) packages, and usability improvements in the Customer Maintenance Management System (CMMS), which is the application line maintainers use most often. It also addresses 17 of the documented issues that frequently burden maintainers. Usability improvements include navigation, page configuration persistence, and table usage.
- The program also released an urgent fix, ALIS 3.5.2.2, during the summer of 2020 to address a deficiency in the onboard Full Authority Digital Engine Control (FADEC) software – which is the software that converts pilot inputs to engine control – that resulted in ALIS generating up to 40 HRCs during each maintenance debrief. This high rate of HRC recordings was roughly 10 times the normal number. The urgent fix in ALIS 3.5.2.2 filtered the large number of nuisance codes generated by the deficient FADEC software.
- Testing of the planned second quarter ALIS update began July 27, 2020. During flight operations and testing on

the Operationally Representative Environment (ORE), two Category 1 deficiencies were identified. To address the Category 1 and some Category 2 deficiencies, the program installed software fixes on August 14 and 15, 2020. However, flight operations and ORE testing determined that the updates resulted in problems with the Electronic Equipment Logbook (EEL) viewer and the install tool, and that the release required too many manual workarounds to recommend release to the field. After adding software fixes, the program completed a third round of flight operations and ORE testing in early October 2020. The program planned to install the combined first and second quarter updates at Nellis AFB in October 2020 and release it to the fleet in November 2020.
  - Content of the second quarter update includes an auto-loader that allows ALIS administrators to simultaneously complete baseline software installations on up to 24 PMAs, a wireless barcode scanner that improves the supply chain receipt process, Windows 10 upgrade, and improvements in system security. Usability improvements include better PMA synchronization with Standard Operating Units (SOU), automation in DTR workflow, and improvements in the PAIRS air vehicle transfer process related to parts management.
- In October 2020, the program indicated that it would combine the third and fourth quarterly ALIS updates, thus planning to release two updates in 2020 instead of the four planned, with release of the second update occurring approximately 45 days after the first. The program planned to begin flight test of the combined release in December 2020 with fleet release expected in February 2021.
  - Content of the third quarterly update now prioritizes correction of more deficiencies identified by the users, including PAIRS handling of EELs, synchronization of PMAs with the Maintenance-Vehicle Interface, workflow handling of Time Compliance Technical Directives and deferred work orders, and the transfer of air vehicle data between SOUs. The fourth quarterly update also focuses on improving ALIS cybersecurity. The program also plans to release a capability allowing maintainers to print technical data from PMAs or workstations.
- The Integrated Test Force (ITF) at Edwards AFB stood up an unclassified SOU. Although DOT&E has recommended this for a number of years and it does expand the ability of the ITF to test ALIS capabilities, the ITF and ORE cannot test all ALIS capabilities using operationally representative quantities of data, as would be available from operational or OT units. The ITF has limited ability to process classified data, while the ORE cannot process any classified material. For this reason, ALIS releases recommended for fielding are generally tested at Nellis AFB before enterprise-wide fielding.

Assessment

- Although the program has released several versions of ALIS 3.5 in 2020, the program has not been able to generate quarterly updates as planned. While some delays are attributable to restrictions imposed by COVID-19, others are related to overall software quality and stability. Each delay in a quarterly release has had a waterfall effect on those following it. Improvements contained within ALIS 3.5 releases include enhanced ALIS stability and usability, decreased aircraft debrief times and improvements in EELs inductions, bulk work order sign-off, and AME single work orders, all of which have reduced maintainer workload.
- Although testers responded positively to specific usability and functionality improvements during flight test operations, operational units have provided limited feedback and there is no indication that the ALIS user community has eliminated workarounds.
- Most improvements in ALIS have not eliminated long-standing issues with data quality and integrity which continue to burden maintenainers and ALIS administrators, and is a primary source of workarounds. Although the program has begun to address data quality issues in general (after 8 years of issues), and EELs in particular, more improvements are needed before maintainers will establish trust in ALIS.
- The program has not prioritized a long-standing request from maintainers to provide a mature, easily readable, illustrated parts breakdown for the F-35, such as the Identify-Location tool, that supports CMMS.
- The program has not demonstrated the capability to develop, integrate, test, and release ALIS quarterly updates without also causing significant software stability problems and breaking capabilities that already worked. Although hindered by COVID impacts to personnel availability, DOT&E expects these problems to persist due to flawed software development processes and inherent software stability issues. In October 2020, the program indicated it plans to streamline the contractual vehicle for ALIS so that all phases of development, test, and fielding are covered by one contract. Currently, the program uses separate contracts for development, test, and fielding.
- Unit maintenance personnel rely on PMAs to conduct daily maintenance tasks. PMA availability is not currently tracked at the unit level, which often adds to workload for ALIS users to track down usable PMAs. As PMAs age, PMA tracking becomes more important.
- The JOTT administered ALIS usability surveys to support assessments of ALIS for IOT&E. These surveys provide valuable data and feedback for improving what has been a chronic issue with ALIS at the unit level.
- The program does not have a single operationally representative venue that allows development and testing (to include cybersecurity testing) of ALIS software to improve the quality of hardware and software while decreasing the time required to so.
- Although planned to do so, the program did not transition the ORE to Hill AFB, Utah, in 2020. Instead, the stand up of the ORE at Hill AFB was delayed until the ORE could support ODIN tesitng.

- The program conducted a test of the National ALIS/ODIN Support Center (NASC) at Luke AFB, Arizona. The NASC is intended to decrease the burden on unit-level ALIS administrators by providing centralized administration. The program has not released a report on the results but has indicated that the test successfully completed tasks normally completed by unit-level ALIS administrators in a manner that was transparent to affected units.

ODIN

Activity

- A new F-35 program initiative called ODIN combines efforts from the ALIS Next program, Mad Hatter project from the Air Force's Kessel Run office, and Lockheed Martin's independently funded research and development. ODIN is being led by the F-35 JPO and is designed by the Air Force's Kessel Run office, 309th Software Engineering Group, and the Naval Information Warfare Center, with supporting contracts with Lockheed Martin for data, software, and hardware development. Contracts with Pratt & Whitney are in work to provide the necessary engine data for ODIN.
- ODIN's IOC objective is September 2021 with FOC full system deployment by the end of December 2022. ODIN is planned to be released in multiple stages through agile software development in a cloud environment.
- ODIN will require new hardware and software applications throughout the entire JSF enterprise.
- The ODIN effort requires a number of artifacts to use the Adaptive Acquisition Framework in the September 2020 release of the DoDD 5000.01 and January 2020 release of the DoDI 5000.02. To date, the Capability Needs Statement (CNS) and User Agreement (UA) were submitted to DOT&E for review and comment and both documents were undergoing final signature process within F-35 JPO channels. One of the required documents for this process, the Test Strategy, had not yet been provided to DOT&E.
- A number of candidate hardware solutions have been prototyped to host the ODIN software at the squadron level. These solutions fall into two categories: the ODIN Base Kit (OBK) and the ODIN Deployment Kit (ODK).
- An ODK is being fabricated currently at Lockheed Martin with initial hardware demonstrations planned at Patuxent River Naval Air Station in November, 2020. The candidate OBK is currently at Marine Corps Air Station (MCAS) Yuma, Arizona, undergoing operational testing as a replacement for its squadron-level SOU. This hardware was hosting ALIS 3.5.2.2 as a surrogate for ODIN and to demonstrate interoperability in the transition period between the two programs.
- The program transferred air vehicle data from the squadron SOU to the OBK using a stand-alone Lockheed Martin tool.
- The program has identified several gaps in ODIN development, including immature or non-existent test, acquisition, architecture design, ALIS to ODIN transition, and cloud implementation strategies.

Assessment

- ODIN development is designed around the Adaptive Acquisition Framework, a process codified in formal DoD Instructions. Although the program has two key planning documents in signature coordination – the CNS and UA – other key strategy documents, including an overarching test strategy, has not been provided to DOT&E. Without a roadmap for testing, the DOD will not have an adequate assessment of the overall system development and operational suitability.
- The ODIN software and hardware deployment schedules are even more aggressive and less-defined than the accelerated quarterly ALIS software releases. The schedule for fielding ODIN is high risk.
- The accelerated ODIN software and hardware deployments demonstrated to date appeared to have limited developmental testing and associated test reporting. The lack of ODIN developmental testing may leave system and design flaws undiscovered until after release to the field, requiring significant rework and patching.
- Feedback from users involved in ODIN development is being sought early in the process, but is only being gathered from small audiences, partly for expediency, and partly due to COVID-19 travel restrictions. Including as many users as early as possible in the development process is intented to prevent changes to features of the software required by other users from other Services.
- The gaps in development identified by the program, coupled with limited resources within the JPO, will continue to make the plan to field a fully functional ALIS replacement in September 2021 high risk.

Live Fire Test and Evaluation

F-35 Vulnerability to Kinetic Threats

Activity

- In April 2018, Lockheed Martin delivered the F-35 Vulnerability Assessment Report summarizing the force protection and vulnerabilities of all three F-35 variants, and the F-35 Consolidated LFT&E Report, which summarizes the live fire test and analysis efforts supporting the vulnerability assessments.

Assessment

- DOT&E will publish an independent evaluation of the vulnerabilities of the F-35 aircraft variants to expected and emerging threats in the combined IOT&E and LFT&E report to support the Full-Rate Production decision.

F-35 Vulnerability to Unconventional Threats

Activity

- In FY20, the Naval Air Warfare Center Aircraft Division at Pax River completed system-level testing of the F-35B variant to evaluate tolerance to electromagnetic pulse (EMP) threats.

- To assess the protection capability of the Generation (Gen) II Helmet-Mounted Display System (HMDS) against chemical-biological agents, the JPO completed a comparison analysis of HMDS materials with those in an extensive DOD aerospace materials database.

Assessment

- System-level EMP testing was done to the 6 decibel threat level defined in Military Standard 2169B. Only minor, recoverable system upsets were recorded.
- To assess the protection capability of the Gen II HMDS against chemical-biological agents, the JPO completed a comparison analysis of HMDS materials with those in an extensive DOD aerospace materials database. Analysis shows that the materials used in the F-35 protective equipment can survive exposure to chemical agents and decontamination processes; however, the decontamination process of the HDMS has not been demonstrated and must be tested as part of Block 4 testing.

F-35 Gun Lethality

Activity

- The Air Force delivered two reports to DOT&E detailing the ground and air-to-ground lethality tests.
- The Navy is completing the analysis for air-to-ground engagement gun burst lethality.

Assessment

- DOT&E will provide an independent F-35 gun lethality assessment after the Navy completes the analysis for air-to-ground engagement gun burst lethality against the remaining ground targets as specified in the LFT&E Strategy to support the Full-Rate Production decision.

Cybersecurity Operational Testing

Activity

- The JOTT continued to accomplish testing to support IOT&E based on the cybersecurity strategy approved by DOT&E in February 2015.
- The JOTT conducted cybersecurity weapons interface testing of the F-35 air vehicle (AV) in July 2019 and July 2020 at the Lockheed Martin Mission System Integration Laboratory (MSIL) in Fort Worth, Texas. A test team from Naval Air Station (NAS) Point Mugu, California, provided technical support and tools for the test.
- The JOTT conducted cybersecurity testing of F-35 AV navigation systems in July 2019 at the MSIL, and follow-on F-35 AV navigation testing in April 2020 in an anechoic test chamber at Pax River, Maryland. A test team from Pax River provided technical support and tools for the test.
- The JOTT conducted cybersecurity testing of F-35 AV Variable Message Format in January 2020 at Pax River. A test team from Pax River provided technical support and tools for the test.
- The JOTT conducted a limited ALIS Enterprise cooperative vulnerability and penetration assessment (CVPA) on the ORE in Fort Worth, Texas, and Edwards AFB, California, in July 2020. The JOTT completed an ALIS Enterprise adversarial assessment (AA) in October 2020.
- JOTT cybersecurity tests in 2020 were completed in accordance with their individual, DOT&E-approved test plans.
- Throughout 2020, the JOTT continued to work with stakeholders across the DOD to identify relevant scenarios, qualified test personnel, and adequate resources for conducting cyber testing on AV components and support systems.
- In 2020, the F-35 JPO, JOTT, and the UOTT continued developing a test strategy for assessing cybersecurity of the JSF supply chain. The strategy is being informed by the results of a supply chain Cyber Table Top (CTT) exercise conducted in 2019, a yet to be scheduled deep dive into the overall supply chain, and agreements between the program and contractor test communities. The CTT analyzed the potential threats to two AV systems, plus the possible consequences to F-35 mission capability and suitability of a compromise of production or re-supply of select components within these systems.

Assessment

- While some cybersecurity-related system discrepancies have been resolved, cybersecurity testing during IOT&E continued to demonstrate that some vulnerabilities identified during earlier testing periods have not yet been remedied.
- Despite several successful tests to-date, more testing is needed to assess the cybersecurity of the AV. Actual aircraft, as well as appropriate hardware- and software-in-the-loop facilities, must be used to enable operationally representative AV cyber testing. To this end, the F-35 JPO arranged for an operationally representative F-35 AV at Pax River to facilitate testing in 2020 and will continue to support cybersecurity testing in 2021 and beyond.
- Testing of the JSF supply chain to date has not been adequate. Additional testing is needed to ensure the integrity of hardware and software components for initial production and sustainment of AVs and the maintenance information system, plus resupply of replacement parts. The F-35 JPO is in the process of developing a comprehensive supply chain cybersecurity test strategy that will, in conjunction with the 2019 supply chain CTT, guide future supply chain cybersecurity testing.
- Cybersecurity testing to-date identified vulnerabilities that must be addressed to ensure secure ALIS, training systems, USRL, and AV operations.
- The F-35 JPO intends to use a SecDevOps and agile software construct with frequent software updates to the field in support of the ODIN path forward. The Block 4, 30 and 40 Series construct is also providing more frequent OFP updates to the combat forces than SDD. An increased frequency of new software deployments may stress the capacity of cybersecurity test teams to thoroughly evaluate each update. Under these new constructs, the relevance of cybersecurity

testing of the software development environments will increase.

- Per the F-35 JPO, the AV is capable of operating for up to 30 days without connectivity to ALIS via the SOU. In light of current cybersecurity threats and vulnerabilities, along with peer and near-peer threats to bases and communications, DOT&E required the F-35 program and Services to conduct testing of aircraft operations without access to the ALIS SOU for extended periods of time, with an objective of demonstrating the 30 days of operations. The program is currently planning for a test of the ALIS Contingency Operations Plan in 2021, which addresses standardized procedures for the lack of connectivity scenarios.

Recommendations

The program (i.e., F-35 JPO, Services, Lockheed Martin) should:

1. Complete the remaining development and VV&A of the JSE as soon as possible to enable the required IOT&E trials to be completed.
2. Fully fund new and upgrades to the RSEs, JSE, and OABS systems to meet adequate test requirements for each C2D2 release of capability.
3. Program adequate funding to develop and sustain robust laboratory and simulation environments, along with adequate VV&A plans that include the use of data from representative open-air missions in support of developmental and operational testing.
4. Per the DOT&E TEMP, Increment 1 approval memo:
   - Fully fund, develop, and update the detailed plan to modify all OT aircraft with the capabilities, life limit, and instrumentation, including OABS requirements.
   - Complete a 30-day demonstration of flight operations without ALIS connectivity by mid-CY21.
   - Complete collaborative government/contractor cybersecurity testing of the contractor-based supply chain by mid-CY21.
   - Align the components of the F-35 air system delivery framework for each increment of capability to allow enough time for adequate testing of the fully representative system that is planned to be fielded.
   - Define the Scope and Prioritization of Cyber Test Resources for Evaluation process for Block 4 cyber test prioritization.
   - Conduct an OT Readiness Review prior to the start of operational test periods.
5. Quickly complete development of the requirements for the Block 4 software integration lab and USRL while ensuring adequate lab infrastructure to meet the aggressive development timelines of C2D2 and the operational requirements of the Block 4 F-35, both 30 and 40 Series aircraft.
6. Continue to pursue maintenance system improvements, especially for common processes that are distributed amongst many different NMC-M drivers, such as low observable repairs and adhesive cure times.
7. Continue to resource and develop alternate sources of repair (including organic repair) for current and projected NMC-S drivers to sustain improvements in NMC-S.
8. Continue to expedite fixes to EELs.
9. Provide ALIS users with the ability to track PMA availability at the unit level.
10. Include surveys to evaluate ALIS usability during Block 4, 30 and 40 Series suitability testing.
11. Prioritize development of a mature, easily readable, illustrated parts breakdown for the F-35, such as the Identify-Location tool, based on feedback from field users.
12. Develop an overarching test strategy for ODIN hardware and software.
13. Develop a single operationally representative venue that allows development and testing (to include cybersecurity testing) of ALIS and ODIN software to improve system quality.
14. Demonstrate Gen III HMDS decontamination procedures during Block 4 testing.
15. Conduct more in-depth cyber testing of the AV and provide a dedicated AV cyber-test asset.
16. Correct program-wide deficiencies identified during cybersecurity testing in a timely manner.

Global Command and Control System – Joint (GCCS-J)

Executive Summary

- In FY20, the Global Command and Control System – Joint (GCCS-J) Program Manager sustained the existing GCCS-J v4.3 baseline and developed GCCS-J Global v6.x. The Joint Planning and Execution Services (JPES) Program Manager sustained the existing Joint Operation Planning and Execution System (JOPES) v4.3 baseline and developed JPES.
- In January 2020, the Defense Information Systems Agency (DISA) halted development of the GCCS-J Enterprise Modernization program after a yearlong effort. Moving forward, DISA plans to evolve technical capabilities and implement an enterprise-centric architecture as part of the GCCS-J v6.x program.

GCCS-J Global

- The Joint Staff and DISA sunset GCCS-J v4.3 in September 2020 prompted all users to migrate to version 6.x.
- Coronavirus (COVID-19) pandemic restrictions prevented the Joint Interoperability Test Command (JITC) from validating fixes to defects identified during previous operational testing and from determining GCCS-J v6.0.1.11 stability in the operational environment, prior to the GCCS-J v4.3 sunset.
- COVID-19 restrictions also prevented JITC from completing cybersecurity testing of GCCS-J v6.0.1.6 at U.S. Southern Command (USSOUTHCOM), Miami, Florida.

JPES

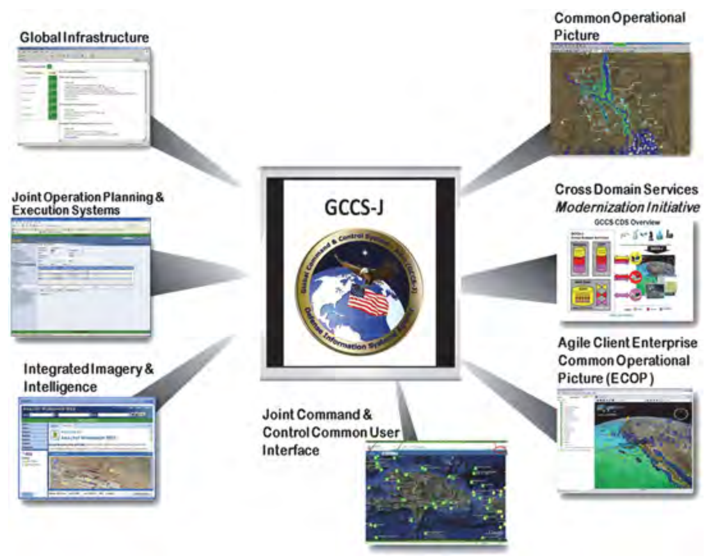
- DISA rebaselined JPES in November 2019. The Program Office plans to use "agile" software processes to develop the system.

System

GCCS-J consists of hardware, software (both commercial off-the-shelf and government off-the-shelf), procedures, standards, and interfaces that provide an integrated, near real-time picture of the battlespace that is necessary to conduct joint and multi-national operations. Its client/server architecture uses open systems standards and government-developed military planning software. GCCS-J comprises GCCS-J Global and JPES.

GCCS-J Global

- GCCS-J v6.0.1.11 is intended to provide back-end services, databases, and system administration functions. Agile Client v5.2 is intended to provide visualization and presentation of GCCS-J mission applications and functionality to the user. The Program Office is using agile development to evolve GCCS-J Global v6.0.1.11, using incremental Maintenance Releases (MRs) to expand capabilities available to the warfighter.



JPES

- DISA is developing JPES to replace the legacy JOPES v4.3 baseline. JPES provides all of the functionality of the current JOPES in a modernized architecture.

Mission

Joint Commanders use the GCCS-J to accomplish command and control.

GCCS-J Global

- Commanders use GCCS-J to:
  - Link the National Command Authority to the Joint Task Force, Combatant Commanders, and Service-unique systems at lower levels of command
  - Process, correlate, and display geographic track information integrated with available intelligence and environmental information to provide the user a fused battlespace picture
  - Provide integrated imagery and intelligence capabilities (e.g., battlespace views and other relevant intelligence) into the common operational picture and allow commanders to manage and produce target data using the joint tactical terminal
  - Provide a missile warning and tracking capability
- Air Operations Centers use GCCS-J to:
  - Build the air picture portion of the common operational picture
  - Correlate or merge raw track data from multiple sources
  - Associate raw electronics intelligence data with track data
  - Perform targeting operations

JPES

- Commanders use JPES to:
  - Translate policy decisions into operations plans that meet U.S. requirements to employ military forces
  - Support force deployment
  - Conduct contingency and crisis action planning

Major Contractors

- Government Integrator: DISA – Fort Meade, Maryland
- Software Developers:
  - Northrop Grumman – Arlington, Virginia
  - Leidos – Arlington, Virginia
  - InterImage – Arlington, Virginia
  - CSRA – Falls Church, Virginia

Activity

GCCS-J Modernization

- In January 2020, DISA halted development of the GCCS-J Enterprise Modernization program after a yearlong effort. Moving forward, DISA plans to evolve technical capabilities and implement an enterprise-centric architecture as part of the GCCS-J v6.x program.

GCCS-J Global

- The Program Office approved the following releases in FY20:
  - v6.0.1.5 MR in October 2019
  - v6.0.1.6 MR in December 2019
  - v6.0.1.7 MR in February 2020
  - v6.0.1.8 MR in May 2020
  - v6.0.1.9 MR in May 2020
  - v6.0.1.10 MR in June 2020
  - v6.0.1.11 MR in September 2020
  - v6.0.1.12 MR in September 2020
  - v6.0.1.13 MR in November 2020
- JITC conducted a cooperative vulnerability and penetration assessment of GCCS-J v6.0.1.6 at USSOUTHCOM February 5 – 14, 2020. COVID-19 restrictions prevented JITC from completing the adversarial assessment. JITC is planning to complete GCCS-J v6.x cybersecurity testing in 4QFY21.
- JITC conducted a user assessment of the JPES Collaboration Tool (JCT), a component of GCCS-J v6.0.1.11 MR, at 15 sites, August 3 – 18, 2020. DISA developed the JCT to replace the legacy NEWSGROUP capability in GCCS-J v4.3. In accordance with DOT&E policy, this low-risk upgrade warranted a level I operational test, which did not require a DOT&E-approved test plan.
- Following poor results during the user assessment, DISA removed the JCT capability from the GCCS-J v6.0.1.11 MR and extended the GCCS-J Authority to Operate to allow continued use of the GCCS-J v4.3 NEWSGROUP capability.
- The Joint Staff and DISA sunset GCCS-J v4.3 in September 2020 prompting all users to migrate to version 6.0.12.

JPES

- DISA rebaselined JPES in November 2019. The Program Office plans to use "agile" software processes to develop the system.

Assessment

GCCS-J Global

- COVID-19 restrictions prevented JITC from validating OT&E fixes to defects identified during previous operational testing and from determining GCCS-J v6.0.1.11 stability in the operational environment, prior to the GCCS-J v4.3 sunset.
- The JCT user assessment showed that the capability did not support JPEC collaboration. Thirteen problem reports remained open at the conclusion of testing, of which seven resulted in complete or partial mission failure with no means to resolve and mitigate the deficiencies. The DISA developmental test program should have discovered many of these defects prior to the JCT user assessment.

Recommendations

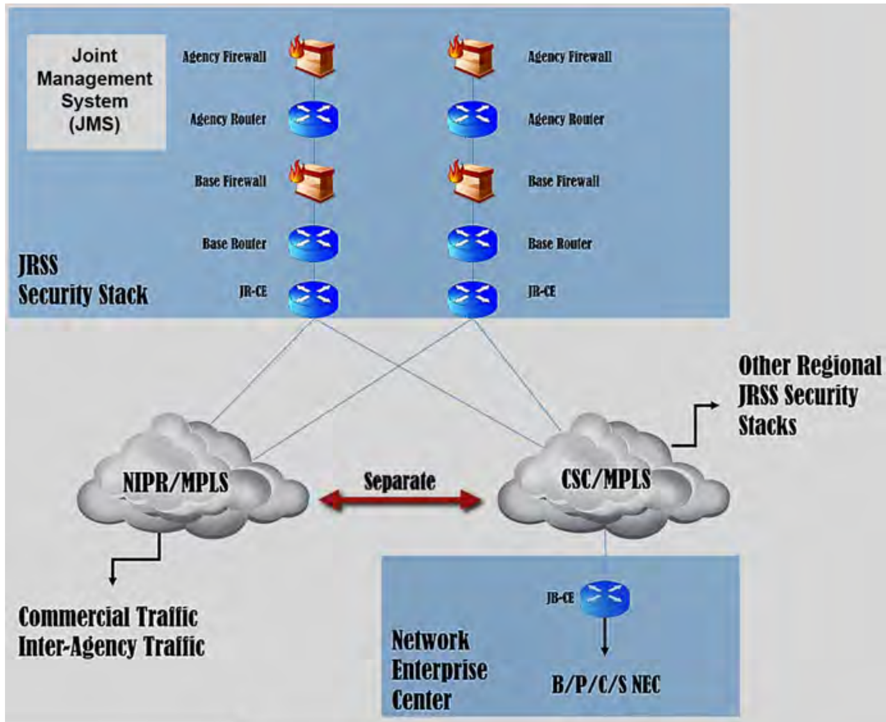
DISA should:

1. Resolve JCT Priority 1 and 2 problem reports.
2. Operationally test GCCS-J v6.1 at Combatant Command sites to validate Program Office fixes to defects identified during previous operational testing and to determine system stability in the operational environment.
3. Complete cybersecurity testing on the operational version of GCCS-J Global v6.1, in accordance with DOT&E-approved cybersecurity test guidelines.
4. Continue to improve the GCCS-J developmental test program.

Joint Regional Security Stack (JRSS)

Executive Summary

- In February 2020, the DOT&E Advanced Cyber Operations (ACO) team and the Defense Information Systems Agency (DISA) Red Team, in coordination with the Joint Regional Security Stack (JRSS) Program Management Office (PMO), conducted a cyber event. This event was to evaluate the cyber posture of SIPRNET-JRSS (S-JRSS), the SIPRNET Joint Management Network (S-JMN), and the SIPRNET-Joint Management System (S-JMS). The event resulted in poor cybersecurity findings, which contributed to the PMO shutting down existing S-JRSSs and the Digital Modernization Infrastructure Executive Committee (DMI EXCOM) delaying future S-JRSS deployments to FY23.
- Proven, effective cybersecurity performance in operationally realistic testing has not been a criterion for NIPRNET (N-JRSS) fielding. Since 2016, N-JRSS operational assessments have continually shown that N-JRSS is unable to help network defenders protect DOD Component networks against operationally realistic cyberattacks.
- U.S. Cyber Command (USCC), with DOT&E assessment support, is helping the Services pilot implementation of Zero Trust architectures as the DOD evaluates a more data-centric security model. This new model promises more effective cybersecurity than the perimeter defenses currently offered by JRSS.



B/P/C/S - Base, Post, Camp, Station
CSC - Carrier Supporting Carrier
JB-CE - Joint Base - Customer Edge
JR-CE - Joint Router- Customer Edge
JRSS - Joint Regional Security Stack
MPLS - Multi-Protocol Label Switching
NEC - Network Enterprise Center
NIPR - Non-classified Internet Protocol Router Network

Capabilities and Attributes

- JRSS is a suite of equipment intended to perform firewall functions, intrusion detection and prevention, enterprise management, and virtual routing and forwarding, as well as to provide a host of network security capabilities. JRSS is not a program of record. Despite its complexity, the DOD has treated JRSS as a "technology refresh," and has not funded the personnel and training typically associated with DOD acquisition programs of record.
- The JRSS is intended to centralize and standardize network security into regional architectures instead of locally distributed, non-standardized architectures at different levels of maturity and different stages in their lifecycle at each military base, post, camp, or station.
- Each JRSS includes many racks of equipment designed to allow DOD components to ingest, process, and analyze very large network data flows.
- A key component of JRSS is the Joint Management System (JMS), which provides centralized management of cybersecurity services required for DOD Information Network (DODIN) operations and defensive cyber operations.
- JRSS is currently operational on NIPRNET (N-JRSS). A SIPRNET (S-JRSS) version was planned with several being installed, but not used operationally, in 2016.

Mission

The DOD intends to use JRSS to enable DOD cyber defenders to continuously monitor and analyze the DODIN for increased situational awareness to minimize the effects of cyberattacks while ensuring the confidentiality, integrity, availability, and non-repudiation of data.

Vendors

DISA is the lead integrator for JRSS. The table on the next page lists the current Original Equipment Manufacturers (OEMs) of the JRSS capabilities.

OEM	OEM Location
A10	San Jose, California
Axway	Phoenix, Arizona
BMC	Houston, Texas
Bro	Berkeley, California
Cisco	San Jose, California
Citrix	Fort Lauderdale, Florida
Corelight	San Franciso, California
CSG International	Alexandria, Virginia
Dell	Round Rock, Texas
EMC	Santa Clara, California
F5	Seattle, Washington
Fidelis	Bethesda, Maryland
Gigamon	Santa Clara, California
HP	Palo Alto, California
IBM	Armonk, New York
InfoVista	Ashburn, Virginia
InQuest	Arlington, Virginia
Juniper	Sunnyvale, California

OEM	OEM Location
Micro Focus	Rockville, Maryland
Microsoft	Redmond, Washington
Niksun	Princeton, New Jersey
OPSWAT	San Francisco, California
Palo Alto	Santa Clara, California
Quest	Aliso Viejo, California
Raritan	Somerset, New Jersey
Red Hat	Raleigh, North Carolina
Red Seal	Sunnyvale, California
Riverbed	San Francisco, California
Safenet	Belcamp, Maryland
Symantec	Mountain View, California
Trend Micro	Irving, Texas
Van Dyke	Albuquerque, New Mexico
Veeam	Columbus, Ohio
Veritas	Mountain View, California
VMWare	Palo Alto, California
Zeek (formerly Bro)	Berkeley, California

Activity

- JRSS is not a program of record and does not have a Test and Evaluation Master Plan (TEMP).
- In December 2019, the PMO conducted an N-JRSS Tools Rationalization meeting where representatives of the JRSS operational community met to discuss how the portfolio of tools available in JRSS are used with the goal to identify redundant and/or unused capabilities.
- In February 2020, DOT&E and the DISA Red Team, in collaboration with the PMO, examined the cybersecurity of four deployed S-JRSS stacks that did not yet have operational traffic flowing, the S-JMN, and the S-JMS.
- The Joint Interoperability Test Command (JITC) planned a cooperative vulnerability and penetration assessment (CVPA) of N-JRSS for February 2020. This event was postponed due to delays in funding and travel authorizations for critical support personnel. JITC rescheduled the event in July 2020 but could not conduct it due to coronavirus (COVID-19) pandemic travel restrictions.
- JITC is currently planning a fully remote CVPA in October 2020 to work around travel restrictions.
- In January-March 2020, the JRSS PMO conducted a pilot implementation of a Break and Inspect (B&I) capability for selected encrypted traffic outbound to the internet on two N-JRSS production stacks within the continental United States (CONUS).
- In April 2020, the DOD Chief Information Officer (CIO) published an update to the JRSS Functional Requirements Document, in response to a DOD Inspector General recommendation to map the test measures to requirements. JRSS does not have documented operational requirements.
- In June 2020, the Air Force stopped funding their 346th Test Squadron's support of JRSS testing.
- In August 2020, the DMI EXCOM (formerly Joint Information Environment EXCOM) approved a reduced spending plan for FY22 which defers S-JRSS efforts to FY23. In the interim, the DOD will consider alternative mid-tier defensive cybersecurity solutions.
- In September 2020, DOT&E began a series of validation events to support the cybersecurity evaluation of USCC Zero Trust pilots being executed by the Services.

Assessment

- Migrations to N-JRSS are not contingent upon operational test results and have continued despite DOT&E recommendations to suspend them until the stacks are shown to be effective in operational testing. Since 2016, N-JRSS operational assessments have continually shown that N-JRSS is unable to help network defenders protect DOD Component networks against operationally realistic cyberattacks.
- A report from the December 2019 N-JRSS Tools Rationalization meeting has not yet been released to external participants. Appropriate and effective Standard Operating Procedures (SOP) and training for JRSS network defense operations have still not been developed.
- The February 2020 cybersecurity event for S-JRSS, the S-JMN, and the J-JMS produced poor cybersecurity findings

that contributed to the decision to shut down the existing S-JRSS stacks and delay full deployment. Users had not yet migrated behind the existing stacks deployed in 2016.

- The PMO's N-JRSS B&I pilot focused on network performance and degradation, and showed minimum performance effect during high bandwidth availability in CONUS only.
  - No tests were conducted to determine latency affects over long haul communications, or on latency sensitive applications and tactical edge platforms.
  - The pilot did not evaluate cybersecurity risks of the B&I capability or if it can contribute to effective cyber defense, which are critical factors in adopting the capability.
  - Furthermore, the DOD Components requested that the B&I capability provides visibility into traffic that traverses within the DODIN vice internet bound traffic. This pilot only collected data on the latter.
  - In September 2020, the JRSS Senior Advisory Group voted to put implementation of JRSS B&I on hold until further analysis of the capability, and how it should be used across the DOD, is conducted.
- JITC has been unable to conduct test events in 2020 initially due to delays in funding and travel authorizations, and then due to COVID-19-related travel restrictions. JITC has shifted focus to conducting remote testing where possible, with the support of the DOD CIO and the PMO.
- Although the DOD CIO has mapped test measures to functional requirements, an operational requirements document still does not exist. In order to fully address users' and mission owners' needs during testing, operational requirements must be documented.
- Because JRSS is already deployed, and to minimize the need to travel, the DOD CIO, the JRSS PMO, JITC, and DOT&E are working to streamline JRSS evaluation by taking better advantage of existing operational data elements and focusing test events on the risks associated with system changes intended to improve mission effectiveness.
- Given the effect of COVID-19, user migrations and testing schedules are curtailed, presenting an opportunity to focus on operator training and streamlining the JRSS capabilities to improve user experience and mission effectiveness. Operator proficiency is a persistent shortfall identified by operational testing, indicating the JRSS training processes and system usability need improvement.
- The Air Force decision to stop supporting the 346th Test Squadron's participation in JRSS testing caused testers to lose insight into the Air Force's methods, priorities, and topology making evaluation of the Air Force's JRSS use less effective.
- The DOD is evaluating the adoption of a data-centric security model over the traditional network-centric security for the Department. The results of the USCC Zero Trust pilots, which DOT&E is helping assess for cybersecurity through a series of validation events, will be used to guide future directions for mid-tier security. In advance of DOD migrating users to Zero Trust environments, often enabled through software-defined perimeter capabilities, the concept, design, and use of N-JRSS will need to be revised to effectively and suitably support and integrate into the defensive cyber mission.

Recommendations

- The DOD CIO and the DOD Components should:
  1. Continue developing more effective cybersecurity alternatives to JRSS, such as the ongoing pilot work by the Services on implementing Zero Trust architectures and increased focus on developing and maintaining a skilled and trained defensive cyber work force.
  2. Should forgo S-JRSS operations altogether if the Zero Trust architectures prove viable.
  3. Discontinue migrating new users to JRSSs until the system demonstrates that it is capable of helping network defenders to detect and respond to operationally realistic cyberattacks and until the mid-tier cybersecurity analyses from USCC, DOD CIO, the DOD Principal Cyber Advisor, and external consultants inform future directions.
  4. Reevaluate the need for an N-JRSS B&I functional requirement as USCC and DOD CIO analyze how to best use and implement traffic inspection capabilities within the DODIN.
  5. Prioritize training, system usability, and operator proficiency over meeting migration schedule deadlines.
  6. Engage with USCC and Joint Force Headquarters-DODIN to establish a process to regularly update the Functional Requirements Document to reflect Service requirements, funding availability, and the evolving capability needs identified by the mission owners.
  7. Produce an operational requirements document to improve the N-JRSS defense against nation state threats.
- The JRSS PMO, DISA Global, and the DOD Components should:
  1. Continue focus on training and SOP development. Operator training is an important factor for mission success, and recent minimum staffing changes as part of the COVID-19 response make operator competency more important.
- DISA and the DOD Components should:
  1. Verify JRSS operator competency and training to properly configure and use JRSS services prior to new user migrations.
- DISA (JRSS PMO), DOD Components, and JITC should:
  1. Coordinate with the Service cyber commands and operational community to identify real-world testing metrics and data sources to support remote evaluation and supplement operational test data.
- The Air Force should:
  1. Consider restoring funding for JRSS testing to the 346th Test Squadron to represent Air Force interests and knowledge in test planning, test conduct, and real-world operational data collection and analysis for continued JRSS performance evaluation.

Key Management Infrastructure (KMI)

Executive Summary

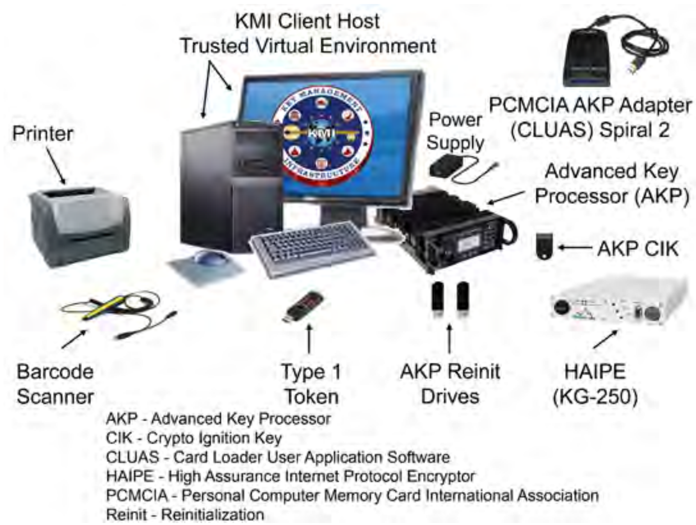
- The National Security Agency (NSA) Senior Acquisition Executive (SAE) authorized full deployment for the Key Management Infrastructure (KMI) Increment 2 in November 2019.
- DOT&E approved the KMI Increment 3 Test and Evaluation Master Plan (TEMP) in August 2020.
- The NSA SAE approved KMI Increment 3 Milestone B in November 2020.

System

- KMI will replace the legacy Electronic Key Management System (EKMS) to provide a means for securely ordering, generating, producing, distributing, managing, and auditing cryptographic products (e.g., encryption keys, cryptographic applications, and account management tools).
- KMI consists of core nodes that provide web operations at sites operated by the NSA, as well as individual client nodes distributed globally, to enable secure key and software provisioning services for the DOD, the Intelligence Community, and other Federal agencies.
- KMI combines substantial custom software and hardware development with commercial off-the-shelf (COTS) computer components. The custom hardware includes an Advanced Key Processor for autonomous cryptographic key generation and a Type 1 user token for role-based user authentication. The COTS components include a client host computer with monitor and peripherals, printer, and barcode scanner.
- The NSA delivered KMI Increment 2 capabilities in two spirals.
- The NSA is delivering KMI Increment 3 in eight planned Agile releases that will enhance existing capabilities and subsume EKMS Tier 0 and Tier 1 cryptographic product delivery into the infrastructure.

Mission

- Combatant Commands, Services, DOD agencies, other Federal agencies, coalition partners, and allies will use KMI to provide secure and interoperable cryptographic key generation, distribution, and management capabilities to support mission-critical systems, the DOD Information Network, and initiatives, such as Cryptographic Modernization.
- Service members will use KMI cryptographic products and services to enable security services (confidentiality, non-repudiation, authentication, and source authentication) for diverse systems, such as Identification Friend or Foe, GPS, and the Advanced Extremely High Frequency Satellite System.



Major Contractors

- Leidos – Columbia, Maryland (Prime for Increment 2, Spiral 2)
- General Dynamics Information Technology – Dedham, Massachusetts
- SafeNet – Belcamp, Maryland

Activity

- The NSA SAE authorized full deployment for the KMI Increment 2 in November 2019.
- The Joint Interoperability Test Command did not conduct any KMI operational tests in FY20.
- DOT&E approved the KMI Increment 3 TEMP in August 2020.
- The NSA SAE approved KMI Increment 3 Milestone B in November 2020.

Assessment

- DOT&E determined KMI to be operationally effective, suitable, and secure for continued operations in 2019, and the current KMI Increment 2 deployed software baseline remained stable in 2020.
- The NSA continues to monitor and resolve problems based on recommendations from previous operational test reports.
  - NSA KMI Operations has recurring staffing shortages that affect long-term system sustainment.

- The NSA KMI help desk, which supports DOD agency and external (non-DOD) users, lacks adequate knowledge of the system and is subject to high staff turnover rates.
- Long-standing KMI configuration management problems remain that require experienced system and database administration, rigid process adherence, adequate staffing, and monitoring to sustain configuration.

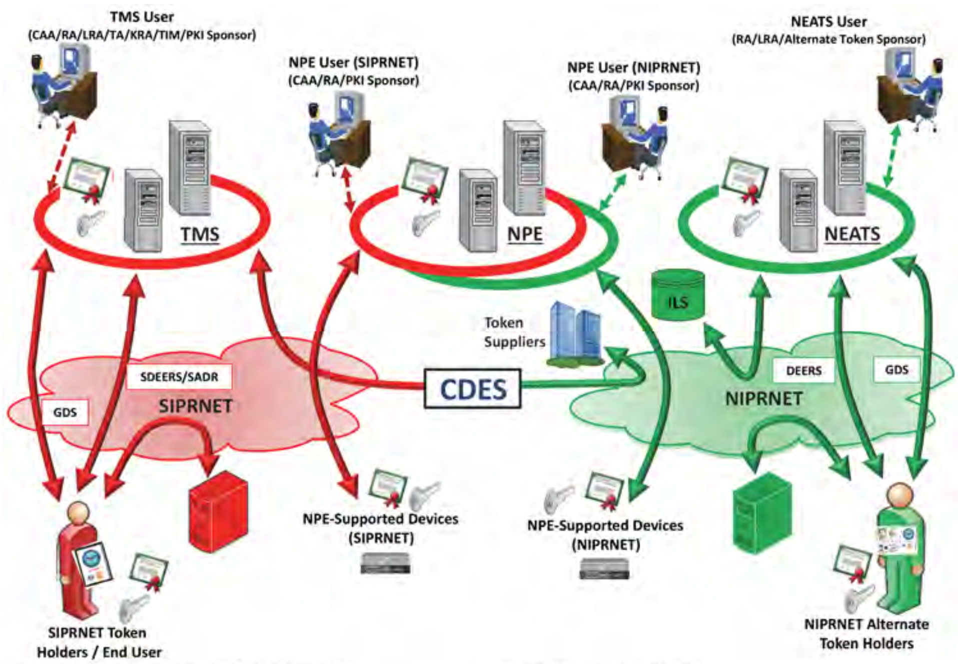
• The KMI Test Infrastructure (TI) provides a safe laboratory for evaluating KMI software builds; however, the KMI TI is not maintained in the same configuration as the operational KMI. This limits the KMI TI users' ability to accurately identify problems prior to deploying a new KMI version to the operational system.

Recommendations

• The KMI Program Management Office should:
  1. Continue to resolve system defects and sustainment problems.
  2. Maintain the KMI TI to the same degree as the operational environment.

• The NSA KMI Operations should:
  1. Improve KMI configuration management and long-term sustainment.
  2. Reassess KMI Operations and help desk staffing to ensure that it can support all existing and planned new capabilities, networks, sites, and users.

Public Key Infrastructure (PKI) Increment 2



CAA - Certification Authority Administrator
CDES - Cross Domain Enterprise Service
DEERS - Defense Enrollment Eligibility Reporting System
GDS - Global Directory Service
ILS - Integrated Logistics System
KRA - Key Recovery Agent
LRA - Local Registration Authority
NEATS - NIPRNET Enterprise Alternate Token System
NIPRNET - Non-classified Internet Protocol Router Network
NPE - Non-Person Entity
RA - Registration Authority
SADR - Secret Authoritative Data Repository
SDEERS - Secret Defense Enrollment Eligibility Reporting System
SIPRNET - Secret Internet Protocol Router Network
TA - Trusted Agent
TIM - Token Inventory Manager
TMS - Token Management System

Executive Summary

- The Public Key Infrastructure (PKI) Program Management Office (PMO) and Defense Information Systems Agency (DISA) migrated PKI's Token Management System (TMS) from DISA physical hosting to a virtualized environment in February through March 2020.
- DOT&E published the PKI Increment 2, Spiral 4 Limited User Test (LUT) Report in April 2020.
- The PKI PMO and Joint Interoperability Test Command (JITC) had planned to conduct an Increment 2 FOT&E in FY20; however, the coronavirus (COVID-19) pandemic affected test planning and site participation, delaying the test event.
- DOT&E approved the PKI Increment 2 FOT&E plan in October 2020.

System

- DOD PKI provides for the generation, production, distribution, control, revocation, recovery, and tracking of public key certificates and their corresponding private keys. By controlling the distribution of encryption, identity, signing, and device certificates and keys, DOD PKI helps ensure only authorized individuals and devices have access to networks and data, which supports the secure flow of information across the DOD Information Network as well as secure local storage of information.
- The National Security Agency (NSA) deployed PKI Increment 1 on the NIPRNET with access control provided through Common Access Cards (CACs) issued to authorized personnel.
- The NSA has developed and is deploying PKI Increment 2 in four spirals on SIPRNET and NIPRNET. The NSA delivered the SIPRNET TMS in Spirals 1, 2, and 3. Spiral 4 is intended to deliver the NIPRNET Enterprise Alternate Token System (NEATS) and Non-Person Entity (NPE) NIPRNET and SIPRNET capabilities.
  - NEATS is intended to provide confidentiality, integrity, authentication, and non-repudiation services by providing a centralized system for the management of NIPRNET certificates on NEATS tokens for privileged users, which includes System Administrators, groups, roles, code signing, and individuals not eligible to receive CACs. NEATS provides token registration, issuance, personnel identification number reset, revocation, and key recovery. The private keys are stored on the token, which is a smartcard embedded with a microchip.
  - The NPE system issues certificates to large numbers of NPE devices (e.g., hardware and virtual devices and software applications) using both manual and automated methods. These certificates help ensure only authorized devices are allowed to access DOD networks. NPE provides authorized System Administrators and Registered Sponsors with the capability to obtain device certificates singularly or in bulk without the need for PKI registration authority approval.
  - The NSA developed the NEATS with the Defense Manpower Data Center (DMDC) and NPE with operational support from DISA, which provide PKI support for the DOD. DMDC also manages the Defense Enrollment Eligibility Reporting System for the NIPRNET and SECRET Defense Enrollment Eligibility Reporting System for the SIPRNET, the authoritative sources for personnel data.
  - NPE and NEATS use commercial and government off-the-shelf hardware and software hosted at DISA and DMDC operational sites.

Mission

- Commanders at all levels use DOD PKI to provide authenticated identity management via personal identification number-protected CACs or SIPRNET or NEATS tokens to enable DOD members, coalition partners, and other authorized users to access restricted websites, enroll in online services, and encrypt/decrypt and digitally sign email.
- Military operators, communities of interest, and other authorized users use DOD PKI to securely access, process, store, transport, and use information, applications, and networks.
- Military network operators use NPE certificates for workstations, web servers, and devices to create secure network domains, which facilitate intrusion protection and detection.

Major Contractors

- General Dynamics Mission Systems – Dedham, Massachusetts (Prime for TMS and NPE)
- Global Connections to Employment – Lorton, Virginia (Prime for NEATS)
- SafeNet Assured Technologies – Abingdon, Maryland
- Giesecke and Devrient America – Twinsburg, Ohio

Activity

- In accordance with a DOT&E-approved test plan, JITC conducted a LUT of PKI Increment 2 capabilities, including the Spiral 4 NPE and NEATS functionalities in September through November 2019. The LUT examined the NEATS on NIPRNET, the NPE enterprise certificate issuance and management system deployed in both the NIPRNET and SIPRNET environments, and TMS sustainment on SIPRNET.
- The PKI PMO updated the lifecycle sustainment plan and the transition plan with the Services and hosting organizations in FY20.
- The NSA established a token evaluation process and chartered a token evaluation working group to address token compatibility problems found in operational use and testing in FY20.
- The PKI PMO and DISA migrated PKI's TMS from DISA physical hosting to a virtualized environment in February through March 2020.
- DOT&E published the PKI Increment 2, Spiral 4 LUT Report in April 2020.
- The PKI PMO and JITC intended to conduct an Increment 2 FOT&E in FY20; however, COVID-19 affected test planning and site participation, which delayed the test event into FY21.
- DOT&E approved the PKI Increment 2 FOT&E plan in October 2020.
- The PKI PMO delayed the planned Increment 2 Full Deployment Decision from December 2020 to 4QFY21 due to COVID-19.

Assessment

- The DOT&E assessments from the PKI Increment 2, Spiral 4 LUT are as follows:
  - NEATS is:
    - Operationally effective for garrison forces, but not effective for naval afloat and forward operating tactical forces because of compatibility problems with deployed operating systems.
    - Progressing toward being operationally suitable, but is not long-term sustainable because of the lack of backwards compatibility and an architectural design that depends on other systems that do not failover.
    - Not survivable against moderate capability nearsider and advanced capability outsider cyber threats.
  - NPE is:
    - Operationally effective, except for inconsistent performance in the auto-rekey functionality on devices using Enrollment over Secure Transport (EST) protocol.
    - Operationally suitable except for EST protocol use with switches, which displayed a lack of operationalized capability that, along with insufficient user training, contributed to device setup delays and auto-rekey failures.
    - Survivable against limited capability nearsider and outsider threats. The NSA has yet to test NPE against advanced cyber threats.
- The DISA help desk needs improvement, and the DMDC help desk was not prepared to operationally support the PKI Spiral 4 capabilities.
- The NPE test effort and operational deployment is handicapped because vendors have not fully implemented protocols for device enrollment and auto-rekeying, which limits available devices for operational testing, and the DOD lacks enterprise NPE policy and implementation guidance.
- TMS long-term sustainment continues to mature; however, the NSA has yet to fully document or follow the formal security certification assessment process prior to deploying new PKI tokens.

Recommendations

- The PKI PMO, DISA, and DMDC should:
  1. Continue to resolve all high-priority defects and verify acceptability to users prior to the PKI Increment 2 Full Deployment Decision.
  2. Resolve sustainability, help desk training, and logistics problems through transition to DISA and DMDC.
  3. Fix or mitigate cybersecurity findings identified during the LUT.

4. Coordinate with the DOD Chief Information Officer to issue NPE guidance for the Services and Agencies on the intended NPE enterprise-wide implementation for devices, protocol, and portal use.
5. Complete full security certification testing for new PKI tokens, and rigorously follow the certification process for all future token variants to ensure that new tokens are secure prior to deploying them into the operational environment.
6. Conduct comprehensive operational testing of NEATS, NPE, and TMS in virtualized hosting, including cybersecurity adversarial assessments emulating advanced threats.

International Test and Evaluation (IT&E)

Managed by DOT&E, the International Test and Evaluation Program (ITEP) continues to be a valuable tool in addressing warfighter needs. ITEP bilateral and multilateral agreements allow for Cooperative Test and Evaluation (CTE) Project Agreements (PAs); Equipment and Material Transfers; Working Groups; and, unique to ITEP, Reciprocal Use of Test Facilities (RUTF) PAs. ITEP is an important enabler in fielding advanced technologies for U.S. forces, as well as for our allies. Through access to test capabilities of international partners, some key representative technologies that may be tested abroad include hypersonic vehicles, autonomous systems, cyber defenses, and chemical/biological countermeasures.

The United States has bilateral agreements with 11 of its closest allies and 1 multilateral agreement, the Multinational Test and Evaluation Program (MTEP) Memorandum of Understanding with Australia, Canada, New Zealand, and the United Kingdom (UK). During FY20, bilateral discussions continued with two other potential international partners to establish new bilateral agreements. Further progress was made in completing the Trans-Atlantic MTEP, involving France, Germany, Italy, the UK, and the United States. This agreement is structured so more countries may be added after it enters into force.

In FY20, DOT&E approved 16 program documents including: 1 Terms of Reference, 2 CTE PAs, and 13 RUTF PAs. One CTE PA allowed the U.S. Air Force and Army to jointly conduct a unique extreme cold weather test using a Canadian test range. Taking place in January 2020 at Goose Bay Air Base, Canada, personnel from the U.S. Air Force, U.S. Army, and Royal Canadian Air Force tested new equipment, materials, and processes to perform rapid damage assessment and crater repair in extreme cold weather conditions (Figure 1).

Figure 1. American and Canadian airmen pouring rapid setting concrete in Goose Bay, Canada.

This event demonstrated the ability to rapidly repair an airfield as well as the durability of repairs through simulated C-17 airlifter traffic. This test illustrates the value of ITEP in sustaining operational capability under realistic, adverse conditions (Figure 2).

Figure 2. Load testing the rapid setting concrete in Goose Bay, Canada.

Under a RUTF PA, the U.S. Army is testing protective clothing against actual chemical warfare agents using the UK's Porton Man test mannequin. The information collected during this testing will inform fielding decisions for the Uniform Integrated Protection Ensemble Family of Systems.

Under another RUTF PA, the U.S. Navy evaluated the effectiveness of the Canadian CH-147F helicopter and the capability of Canadian Tactical Aviation personnel to conduct realistic mission sets in an electronic warfare threat environment. This test had an added nuance. An Australian pilot was on board the Canadian aircraft during testing to observe for potential Australian acquisition of the Canadian system.

Planning was largely completed this FY for testing a British surface-to-air missile (Sky Sabre) at White Sands Missile Range, New Mexico. Sky Sabre (and several other tests) experienced delays as a result of coronavirus pandemic restrictions and the resultant effects to U.S. range availability and travel restrictions imposed on test personnel. Nonetheless, testing is expected in mid-FY21 which will qualify the missile for operational use. This test program satisfies an urgent operational requirement of the UK and is an illustration of how ITEP strengthens relationships with international partners.

Table 1 lists all bilateral and multinational IT&E projects signed in FY20.

TABLE 1. IT&E PROJECTS IN EFFECT IN FY20		
IT&E PROJECTS	**ENTRY INTO FORCE/EFFECTIVE DATE**	**TEST ACTIVITY DATES AND LOCATIONS**
Weapons Effects against Structural Targets T&E RUTF PA	September 1, 2020	October/November 2020 at Pendine, UK
Next-Generation Oxime T&E RUTF PA	August 4, 2020	October 2020 at Fort Detrick, Maryland
T&E of Protective Ensembles Using the Porton Man CTE PA	May 12, 2020	TBD at Porton Down, UK
SIMULATION DISPLAY Sustainment for Sensors, Weapons, Analysis, and Tactical Display Developments RUTF PA	March 31, 2020	April 2020 at the Naval Research Laboratory, Washington, District of Columbia
Project Raider Data Evaluation RUTF PA	March 11, 2020	March 2020 at Naval Research Laboratory, Washington, District of Columbia
Amendment 5 to the Integrated Air and Missile Defense RUTF PA (Formidable Shield)	March 4, 2020	May 2021 in the Hebrides Range, UK
Amendment 2 to the Electronic Warfare Operational Test RUTF PA	March 2, 2020	July 2022 in the coastal waters of Hawaii
Tactical Armored Personnel Vehicle Testing RUTF PA	February 11, 2020	November 2020 at Aberdeen Proving Grounds, Maryland
CH-146 Radar Warning Receiver Validation and Operational Readiness Assessment RUTF PA*	February 3, 2020	March 2020 at Naval Air Warfare Center, China Lake, California
Combat Archer RUTF PA Annex 2020-01*	January 24, 2020	January 2020 at Eglin AFB, Florida
Amendment 1 to the Simulation Testing of Energy Attenuating Crew Seats RUTF PA	January 23, 2020	TBD by Naval Air Systems Command
Land Platforms Autonomy and Robotics Working Group TOR	January 22, 2020	
Amendment 1 to the Small Arms Ammunition or Related Equipment RUTF PA	January 16, 2020	Ongoing at Army North American Regional Test Center, Independence, Missouri
Distant Spider IV CTE PA*	November 25, 2019	January 2020 at Woomera Test Range, Australia
Heterogeneous Multiphase Reactive Blast T&E RUTF PA	October 30, 2019	November 2019 at Suffield Research Centre, Canada
Amendment 2 to the Field Evaluation of the German Chemical Biological Radiological Nuclear Defence Commands Chemical Response Tactics, Techniques, and Procedures RUTF PA	October 2, 2019	October 2019 at Dugway Proving Grounds, Utah
AFB – Air Force Base; CTE – Cooperative Test and Evaluation; IT&E – International Test and Evaluation; PA – Project Agreement; RUTF – Reciprocal Use of Test Facilities; TOR – Terms of Reference; UK – United Kingdom		
* Testing has completed.		

Army Programs

Army Programs

120-mm Advanced Multi-Purpose (AMP), XM1147

Executive Summary

- DOT&E approved the operational test plan for the XM1147 Advanced Multi-Purpose (AMP) Cartridge, 120-mm, High Explosive Multi-Purpose with Tracer Round, Limited User Test (LUT) in March 2020.
- The Army planned to conduct the LUT at Yuma Proving Ground, Arizona, April 21 – 23, 2020, but canceled the test due to coronavirus (COVID-19) pandemic restrictions. The Army plans to conduct an IOT&E of the AMP round in October 2021.
- The Army plans to conduct an operational assessment (OA) in 3QFY21 after the Milestone C decision. During the OA, soldiers will engage Anti-Tank Guided Missile (ATGM) teams and double reinforced concrete walls (DRCW) in order to assess the two new capabilities prior to the IOT&E.
- The Army began AMP live fire, lethality testing in August 2020, which included: (1) ammunition sensitivity testing to determine any crew vulnerability to an onboard AMP energetic reaction, (2) hard target (bunkers and walls) testing to gather data to evaluate performance against these targets, and (3) armor characterization testing to collect data to support future modeling and simulation (M&S) of AMP performance against anti-armor targets.

System

- The XM1147 120-mm AMP round is a line-of-sight tank round fired from the Abrams tank.
- The Army intends the AMP round to replace the M830 High Explosive Anti-Tank Multi-Purpose with Tracer (HEAT-MP-T), the M830A1 HEAT-MP-T, the M1028 Canister (CAN) round, and the M908 Obstacle Reducing with Tracer (OR-T) round. The AMP round consolidates the capabilities of these four rounds into a single munition.

- The Army desires to add new capabilities for engaging dismounted ATGM teams at extended ranges and breaching DRCW in support of dismounted infantry.
- The AMP round has three defeat modes including Point Detonate (PD), Point Detonate Delay (PDD), and airburst used to defeat a combination of targets including ATGM teams, dismounted infantry, DRCW, light armor, bunkers, obstacles, and armor.
- The Army intends the AMP round to provide the ability to conduct the breach of a DRCW with greater standoff and fewer rounds
- The AMP round will use the same Ammunition Data Link hardware interface integrated on the Abrams platform for the 120-mm M829E4 Kinetic Energy munition.
- The Army developed a training round for the AMP round.

Mission

Commanders employ units equipped with the XM1147 120-mm AMP round to close with and destroy the enemy by direct fire across the full range of military operations.

Major Contractor

Northrop Grumman Defense Systems – Minneapolis, Minnesota

Activity

- The Army planned to conduct the LUT at Yuma Proving Ground, Arizona, April 21 – 23, 2020. The Army canceled the test due to COVID-19 restrictions.
- The Army does not plan to reschedule the LUT. The Army plans to conduct an OA in 3QFY21 after the Milestone C decision. The OA will focus on soldiers engaging ATGM teams and DRCWs to assess the two new capabilities prior to the IOT&E. The Army intends to evaluate a tank crew's ability to perform mission-essential tasks; inform tactics, techniques, and procedures/soldier training packet development; and reduce IOT&E risk.
- The Army plans to conduct an IOT&E in September 2021.
- Live fire and integrated testing was conducted in accordance with a DOT&E-approved Test and Evaluation Master Plan (TEMP) and live fire test plans.
- DOT&E approved the operational test plan for the XM1147 AMP Cartridge, 120-mm, High Explosive Multi-Purpose with Tracer Round LUT in March 2020.
- The Army began AMP live fire, lethality testing in June 2020, which included:
  - Ammunition sensitivity testing to determine any crew vulnerability to an onboard AMP energetic reaction
  - Hard target (bunkers and walls) testing to gather data to evaluate performance against these targets

    - Armor characterization testing to collect data to support future M&S of AMP performance against anti-armor targets
- The Army intends to conduct additional live fire testing against armored vehicle targets to support the 3QFY22 Full-Rate Production decision.

Assessment

- The Army developed a training round for the AMP round. The training round does not replicate the new airburst capability to engage dismounted ATGM teams at extended ranges. Because it is an inert warhead, the training round does not train a gunner's ability to develop subsequent aim points when breaching a DRCW. Under the current training strategy, the only opportunity to train those engagements will be through simulation.
- The Army designed the AMP LUT to focus on the new capabilities for engaging dismounted ATGM teams at extended ranges, and breaching DRCW in support of dismounted infantry by having soldiers fire against those targets as part of the test. The planned OA is expected to focus on these new capabilities.
- AMP lethality testing demonstrated the difficulty for the gunner to determine the aimpoint for subsequent shot placement when breaching a DRCW at the higher requirement angles of obliquity.
- Analysis of live fire test data is ongoing. DOT&E will detail the AMP lethality in the DOT&E report supporting the Full-Rate Production decision.

Recommendations

The Army should:

1. Update the tank crew simulator to support crew training on the new capabilities of the AMP round.
2. Review the obliquity requirement for breaching a DRCW.

Abrams M1A2 System Enhancement Packages (SEPs) Main Battle Tank (MBT) and Trophy Active Protection System (APS)

M1A2 Abrams System Enhancement Package version 3


M1A2 Abrams System Enhancement Package version 2 With Trophy Active Protection System

Executive Summary

- The Army conducted an FOT&E of the Abrams M1A2 System Enhancement Package version 3 (SEPv3) Main Battle Tank (MBT) at Fort Hood, Texas, May 8 – 10, 2019.
- Survivability improvements made to the Abrams M1A2 SEPv3 increased the weight of the vehicle and intensifies recovery and transportation challenges. The Abrams M1A2 SEPv3 demonstrated the program's reliability requirement during operational testing
- In 1QFY20, the Army completed live fire testing of the Abrams M1A2 SEPv3. DOT&E will publish a classified LFT&E report to support the program's production contract award scheduled for December 2020.
- In coordination with DOT&E, the Army drafted the Abrams SEPv4 Test and Evaluation Master Plan (TEMP) and the LFT&E Strategy, which they intend to submit to DOT&E for approval in 2QFY21.
- In June 2020, DOT&E published a report summarizing the performance of the Abrams SEPv2 with Trophy Active Protection System (APS) tested in FY19. The Army is currently planning the test and evaluation program for Abrams SEPv3 with Trophy APS, which is scheduled for 2QFY21 to 4QFY21.

System

Abrams M1A2 System Enhancement Packages

- The Abrams M1A2 is a tracked, land combat, assault weapon system equipped with a 120-mm main gun offering shoot on-the move firepower and joint interoperability (for the exchange of tactical and support information). The Army intends the Abrams tank to be highly survivable and maneuverable with the ability to respond to hostile entities on the battlefield by engaging or avoiding them before they become a threat.
- The Abrams M1A2 SEPv2 is currently fielded. It upgrades the M1A2 by providing increased memory and processor speeds; full color tactical display; digital map capability; compatibility with the Army Technical Architecture; improved target detection, recognition, and identification through incorporation of second-generation forward-looking infrared technology and electronics; Common Remotely Operated Weapon Station (CROWS)-Low Profile (LP); and crew compartment cooling through the addition of a thermal management system.
- The Army began fielding the Abrams M1A2 SEPv3 in 4QFY20. The Abrams M1A2 SEPv3 is an upgrade to the Abrams M1A2 SEPv2. The upgrades include:
  - Power generation and distribution to support the power demands of future technologies
  - Compatibility with joint battle command network
  - Survivability enhancements including Next Evolution Armor and reduction in vulnerability to IEDs including those controlled remotely
  - Improved lethality by providing the ability for the fire control system to digitally communicate with the new large caliber ammunition through use of an ammunition datalink
  - Energy efficiency and sustainment due to the incorporation of an under armor auxiliary power unit (UAAPU)
  - Improved silent watch capability
- The Army plans to begin fielding the Abrams M1A2 SEPv4 in 1QFY25. The Abrams M1A2 SEPv4 is an upgrade to the Abrams M1A2 SEPv3. The upgrades include:
  - An improved Gunner's Primary Sight (GPS) with 3rd Generation Forward Looking Infrared (3GEN FLIR), an Improved Laser Range Finder (LRF), and Color Camera
  - An improved Commander's primary sight with 3GEN FLIR, an improved LRF, laser pointer, and color camera
  - Improved lethality by providing the ability for the fire control system to digitally communicate with the new Advanced Multi-Purpose (AMP) Round
  - Improved firing accuracy through the installation of a Meteorological Sensor
  - Improved onboard diagnostics

Trophy Active Protection System

- The Army intends to install the Trophy APS on the Abrams M1A2 SEPv2 and SEPv3 tanks and field four Armor Brigade sets to Army prepositioned stocks domestically and outside of the continental United States (OCONUS).
- The Army intends the Trophy APS to improve the survivability of ground combat vehicles against anti-tank guided missiles (ATGMs), rocket-propelled grenades (RPGs), and recoilless rifle threats.
- The APS includes search radars to detect, identify, and track incoming threats, and a set of kinetic projectiles intended to intercept the incoming threat.
- The Abrams base armor is expected to absorb threat by-products generated after a successful intercept. The Trophy APS adds approximately 5,000 pounds to the Abrams tanks.

Mission

- Commanders employ units equipped with the Abrams M1A2 SEP tanks to maneuver across the full range of military operations and destroy the enemy by fire. MBT's equipped with APS offer additional defense against ATGMs, RPGs, and recoilless rifle threats.
- The Army intends the Abrams M1A2 SEP tank to defeat and/or suppress enemy tanks, reconnaissance vehicles, infantry fighting vehicles, armored personnel carriers, anti-tank guns, guided missile launchers (ground- and vehicle-mounted), bunkers, dismounted infantry, and helicopters.

Major Contractors

- General Dynamics Land Systems – Sterling Heights, Michigan
- DRS/Rafael – St. Louis, Missouri

Activity

- All testing was conducted in accordance with the DOT&E-approved TEMP and test plans.

Abrams M1A2 System Enhancement Packages

- The Army conducted an FOT&E of the Abrams M1A2 SEPv3 at Fort Hood, Texas, May 8 – 10, 2019. The test unit consisted of Armored elements from the 1st Brigade, 1st Cavalry Division. Test events included long and short duration mounted surveillance missions. The Army conducted a cybersecurity adversarial assessment.
- The Army continued developmental testing in FY20 following conclusion of the May 2019 operational test.
- The Army began fielding the Abrams M1A2 SEPv3 domestically and OCONUS in FY20.
- In 1QFY20, the Army completed live fire testing of the Abrams M1A2 SEPv3 tank. The last test series in the program evaluated the ability of kinetic threats to perforate the internal ammunition compartment and the subsequent reaction of the stowed ammunition on the Abrams M1A2 SEPv3 tank mission and the crew.
- DOT&E will publish a classified Abrams M1A2 SEPv3 LFT&E report in 1QFY21 to support the program's production contract award, scheduled for December 2020.
- In FY20, in coordination with DOT&E, the Army drafted the Abrams SEPv4 TEMP and LFT&E Strategy, which they intend to submit to DOT&E for approval in 2QFY21.

Trophy Active Protection System

- In 4QFY19, the Army completed the testing of the Abrams SEPv2 with Trophy APS, which included maneuver, gunnery, and live fire test events. In June 2020, DOT&E published a classified test report summarizing the Abrams SEPv2 with Trophy APS performance.
- The Army is currently planning the live fire test program for Abrams SEPv3 with Trophy APS. The test program is scheduled for 2QFY21 through 4QFY21.

Assessment

Abrams M1A2 System Enhancement Packages

- The Armored test unit equipped with the Abrams M1A2 SEPv3 accomplished its assigned task in 19 of 20 missions during operational testing. The UAAPU improves the unit's ability to accomplish continuous operations, and the upgrades have not degraded the vehicle's combat capability. Fuel usage when operating the Abrams M1A2 SEPv3 with the UAAPU was 78 percent less than the amount used when running the main engine at idle for the same amount of time.
- Upgrades mitigate the Army's identified capability gaps for the Abrams M1A2 SEPv2.
- The Abrams M1A2 SEPv3 demonstrated 441 mean miles between combat mission failures (MMBCMF), exceeding its requirement of 320 MMBCMF during operational testing.
- The Abrams M1A2 SEPv3 upgrades introduce suitability concerns. Weight growth limits the tank's tactical transportability. The M1A2 SEPv3 is not transportable by current recovery vehicles, tactical bridges, or heavy equipment transporters. Crews had difficulty operating government-furnished equipment. The CROWS-LP thermal sight washed out during operations and had difficulty receiving software reloads. The Army could not reproduce the thermal wash out during testing.
- The UAAPU reduces the acoustic detectability range of the Abrams M1A2 SEPv3 by 62 percent, when compared to the Abrams M1A2 SEPv2.
- DOT&E continues to analyze the live fire test data to evaluate the Abrams M1A2 SEPv3 survivability and force protection against operationally expected threats. DOT&E will publish the M1A2 SEPv3 survivability and force protection evaluation details in a classified report in 1QFY21.

Trophy Active Protection System

- The Abrams SEPv2 with Trophy APS classified report published in June 2020 summarizes the system performance and the test and evaluation recommendations for Abrams SEPv2 with Trophy APS testing. The Army is maturing the existing vulnerability modeling and simulation tools to complement future system assessments.
- The initial live fire test plan for Abrams SEPv3 with Trophy APS does not include relevant threats identified by the Intelligence Community.
- Trophy APS was acquired as an Urgent Materiel Release effort without officially documenting operational requirements, which affected the test planning process.

Recommendations

The Army should:

1. Evaluate the survivability of the Abrams SEPv3 with Trophy APS against the most stressing threats identified by the Intelligence Community .
2. Develop operationally relevant requirements for the Abrams M1A2 tank with and without the Trophy APS.
3. Continue to develop and advance the appropriate modeling and simulation tools needed to support the test planning and evaluation of systems equipped with APS.
4. Consider the findings of the DOT&E and Army LFT&E SEPv3 evaluation reports to enhance the survivability of future Abrams tank upgrades

Aerosol and Vapor Chemical Agent Detector (AVCAD)


Chemring Sensors and Electronic Systems
Smiths Detection Incorporated

Executive Summary

- Due to the coronavirus (COVID-19) pandemic-related supply chain disruptions, the two Aerosol and Vapor Chemical Agent Detector (AVCAD) vendors were not able to conduct much of the planned shakeout testing prior to the contractual delivery dates for systems to support government testing. One of the two vendors was not able to deliver a sufficient number of systems to begin planned test events.
- Government testing to assess sensor detection performance, false alarm rate, the ability to operate in various environmental conditions, and cybersecurity began in August 2020.
- The AVCAD systems experienced reliability failures during false alarm testing that caused the program manager to stop testing and allow the vendors to fix reliability failures and design issues.
- Emerging results from detection performance testing indicate that both vendors' systems require additional development of their detection algorithms to meet detection requirements.

System

- AVCAD is a chemical warfare agent (CWA) and non-traditional agent (NTA) sensor that detects and identifies aerosol and vapor threats. AVCAD is designed to be man-portable or mounted aboard manned vehicles, rotary- and fixed-wing aircraft, and Navy ships. AVCAD was the Next Generation Chemical Detector Increment 1 program.
- AVCAD is designed to operate on battery or platform power and communicate with a remote alarm on closed restricted local area networks provided by the Services or the National Guard Bureau.
- The program is developing and testing two different systems during the engineering and manufacturing development phase of the program. The two systems are the Smiths Detection Incorporated system, which uses high pressure mass spectrometry, and the Chemring Sensors and Electronic Systems, which uses differential mobility spectrometry.

Mission

Joint warfighters equipped with the AVCAD will employ the system to detect CWA and NTA in aerosol and vapor physical states, alert personnel in the event of a chemical attack, and support post attack reconnaissance, surveillance, and decontamination across the full range of military operations.

Major Contractors

- Smiths Detection Incorporated – Edgewood, Maryland
- Chemring Sensors and Electronic Systems – Charlotte, North Carolina

Activity

- Due to COVID-19-related supply chain disruptions, the two AVCAD vendors were not able to conduct planned shakeout testing prior to the contractual delivery dates for systems to support government testing. This led to the discovery of system deficiencies during government testing that may have been identified and addressed prior to the delivery of systems to the government. One of the two vendors was not able to deliver a sufficient number of systems to begin planned test events.
- The Combat Capabilities Development Command (CCDC) Chemical and Biological Center began developmental/operational Chemical Agent Chamber testing in mid-August at Aberdeen Proving Ground South in Edgewood, Maryland. Testing is scheduled to continue through May 2021.
- The CCDC Data and Analysis Center conducted a cooperative vulnerability and penetration assessment (CVPA) from August 3 – 14, 2020, at the Aberdeen Proving Ground South in accordance with the DOT&E-approved test plan.
- The Aberdeen Test Center conducted pilot testing for the developmental False Alarm Test in July 2020, in Baltimore, Maryland. Based on failures of both vendors' systems, the Program Office delayed the test to allow the vendors to fix reliability issues.
- Military Standard 810G and Electro-magnetic Environmental Effects developmental testing began at Dugway Proving Ground, Utah, and White Sands Missile Range, New Mexico, for one of the two vendors' systems in September 2020. The second vendor's systems will be inserted into the tests

upon delivery to the test sites and complete the remainder of the planned testing.

Assessment

- Agent Chamber testing identified performance shortcomings in both vendor systems that should be corrected and demonstrated prior to proceeding to the production and deployment phase of acquisition to meet the Service detection requirements.
- Reliability failures experienced by both vendors' systems during False Alarm Testing will require system design changes to meet the requirement to operate in world-wide environmental conditions.
- The CVPA identified cyber vulnerabilities in both vendor systems.

Recommendations

The AVCAD Program Manager should:

1. Consider shifting the test strategy for this phase of the program to a test-fix-test approach so that identified deficiencies are addressed to enable the test and evaluation of system performance in the full range of expected operational environments prior to progressing to the production and deployment acquisition phase.
2. Consider fully transitioning from the Common Chemical Biological Radiological Nuclear Sensor Interface (CCSI) protocol to the Integrated Sensor Architecture networking protocol to assist with resolution of vulnerabilities identified during the CVPA.

Armored Multi-Purpose Vehicle (AMPV)

Executive Summary

- BAE Systems did not meet the July 2020 first vehicle delivery dates. They are 6-8 months behind original delivery schedule to deliver critical vehicles to support Armored Multi-Purpose Vehicle (AMPV) IOT&E and live fire test events.
- In FY20, the Army continued live fire testing using prototype vehicles across all AMPV variants to support the evaluation of survivability and force protection specification requirements.
- The decision on when to proceed to IOT&E will be made in 1QFY21.
- The Full-Rate Production (FRP) decision is scheduled for 3QFY22.

System

- AMPV will replace the M113 Family of Vehicles program that the Army terminated in 2007.
- The Army intends for the AMPV variants to address the M113 shortcomings in survivability and force protection; size, weight, power, and cooling; and the ability to incorporate future technologies, such as the Army Network.
- AMPV is required to operate alongside the M1 Abrams Main Battle Tank and the M2 Bradley Infantry Fighting Vehicle in the Armored Brigade Combat Team (ABCT).
- The AMPV program has five variants:
  - General Purpose (GP) vehicle from which the unit First Sergeant conducts combat resupply escort, emergency resupply, and casualty evacuation; and provides security for medical evacuation.
  - Mission Command (CD) vehicle to integrate the communications equipment in accordance with the Network Systems Architecture.
  - Medical Treatment (MT) vehicle to provide an armored and mobile protected environment for the unit surgeon and medical staff to provide immediate medical care of casualties or life stabilization triage for casualties prior to their evacuation to more capable facilities.
  - Medical Evacuation (ME) (Ambulance) vehicle to provide protected ambulance evacuation and immediate medical care to the mechanized and armored cavalry units.
  - Mortar Carrier (MC) vehicle to provide immediate, responsive, heavy mortar fire support to the ABCT by utilizing the M121 Mortar System and the M95 Mortar Fire Control System.

Mission

Commanders employ units equipped with the AMPV to provide a more survivable and highly mobile platform to accomplish required operational support missions across the range of military operations. ABCT units use AMPVs to conduct logistical resupply; casualty evacuation and treatment; command post operations; and heavy mortar fire support.

Major Contractor

BAE Systems – York, Pennsylvania

Activity

- Due to production challenges and effects of the coronavirus (COVID-19) pandemic, BAE did not meet the July 2020 first vehicle delivery dates and is 6-8 months behind original delivery schedule to deliver critical vehicles to support AMPV IOT&E and live fire test events.
- DOT&E and the Army Test and Evaluation Command identified 24 items during the limited user test (LUT) in FY19 that BAE should correct and have evaluated during the IOT&E. The program is addressing 21 of the 24 items and intends to have 19 corrections completed prior to the IOT&E.
  - Two of the corrections are not expected to be ready by the IOT&E.
    - The hatch and roof continue to leak. Corrected actions applied did not fix the leaks.
    - A redesign for the mortar carrier cover hatch to address the difficulty in opening is not expected until 1QFY24.
  - Three items have no current industry solutions and will be evaluated if there are future design changes.
    - The footrest in the ME for the medic seat interferes with ingress and egress.

    - The CD internal configuration does not allow multiple mission roles.
    - The MT seating configuration does not facilitate treatment of patients while in transit.
- The Electronic Warfare (EW) and cybersecurity working group continues to meet to determine the scope and scale for EW and outsider threat testing to be conducted during the adversarial assessment and IOT&E.
- IOT&E is scheduled to begin in 4QFY21 and the FRP decision is scheduled for 3QFY22.
- DOT&E approved changes to the Milestone C Test and Evaluation Master Plan on January 21, 2020, to account for vehicle manufacturing delays, pre-COVID-19 impact, and to better leverage previous live fire testing data. The changes included a 27 percent reduction in full-up system-level (FUSL) events and expanded modeling and simulation (M&S) analyses.
    - FUSL testing includes 35 FUSL events, 2 system-level exploitation events, and 12 expanded M&S analyses to support the survivability and crew casualty assessment of the production-representative AMPV variants against operationally expected kinetic threats.
    - FUSL live fire testing is scheduled to start in 2QFY21.
- In 3QFY20, the Army started Phase II system-level live fire testing, which included eight underbody events distributed across all AMPV (prototype) variants with the exception of the MC variant that the Army tested during Phase I in FY19. Phase II testing is scheduled to end in 1QFY21.
- In FY20, in coordination with BAE Systems, the AMPV Program Office continued to address vehicle design vulnerabilities, identified in exploitation and Phase I live fire testing. The effectiveness of the design changes and the ability of the AMPV to meet survivability and force protection requirements will be evaluated during FUSL testing.

Assessment

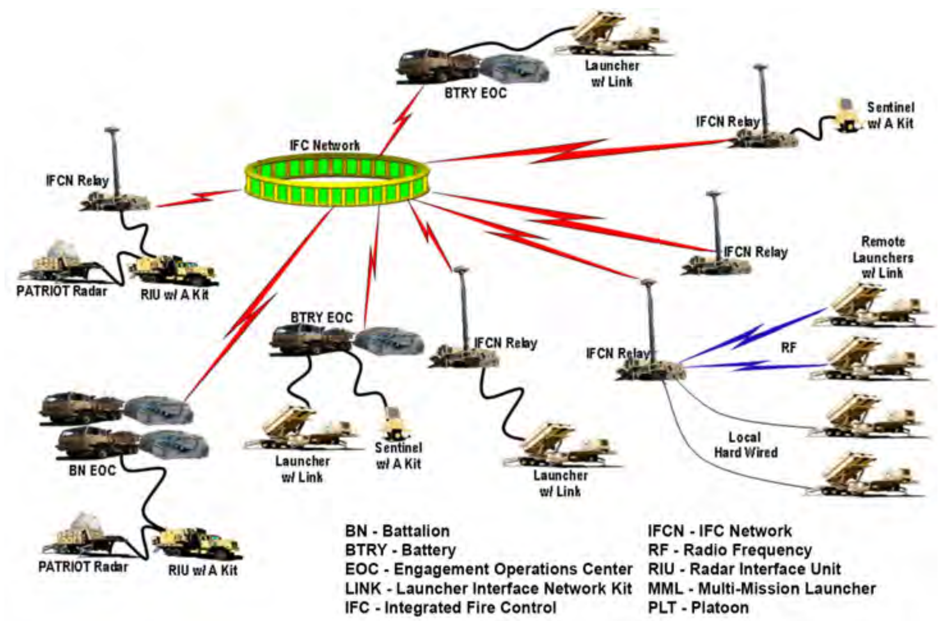
- Further vehicle delivery delays may cause significant risk to the current schedule for the operational and live fire test programs. The decision to proceed with IOT&E as scheduled will be made in 1QFY21.
- Verification of the corrective actions taken to address deficiencies found during the LUT is partially delayed due to the delay in delivery of vehicles for production qualification testing. Some corrective action testing is ongoing.
- DOT&E intends to publish a combined operational and live fire report in FY22 to support the FRP decision.

Recommendations

The Army should:

1. Continue to correct and validate design changes intended to mitigate vehicle and crew vulnerabilities found in live fire testing.
2. Remain event driven to complete the live fire test program and the IOT&E to inform the FRP decision.
3. Conduct a future assessment (e.g., FOT&E) to evaluate the fixes and design changes for the items not corrected prior to the IOT&E.

Army Integrated Air & Missile Defense (AIAMD)



Executive Summary

- The Army conducted a limited user test (LUT) from July to September 2020.
- DOT&E published a classified report to inform a Milestone C decision in November 2020.
- Preliminary indications show improved reliability and stability from the previous LUT conducted in 2016.

System

- The Army Integrated Air & Missile Defense (AIAMD) is a command and control system that integrates sensors, weapons, and a common mission command interface across an integrated fire control network (IFCN).
- The IAMD Battle Command System provides the common mission control capability, integrating Sentinel air surveillance radars, Patriot radars, and Patriot launchers for improved weapon employment.
- AIAMD includes the Engagement Operations Center (EOC), hardware interface kits, and IFCN Relays.
  - EOCs provide the operating environment for all levels of employment. They are equipped with workstations providing a Common Warfighter-Machine Interface for soldiers to monitor and direct sensor employment and engagement of air threats.
  - The IFCN is the primary communications infrastructure to provide fire control connectivity and distributed operations. Hardware interface kits connect adapted Patriot and Sentinel components to the IFCN.
  - The IFCN Relay provides a mobile communications node to extend IFCN connectivity to launchers, sensors, and other EOCs.

Mission

- Army commanders will use AIAMD to provide timely detection, identification, monitoring, and (if required) engagement of air threats in an assigned area of responsibility.
- AIAMD will deploy to provide active protection for the following:
  - Air defense of the homeland
  - Air defense of priority critical assets and locations
  - Air defense of forces

Major Contractors

- Northrop Grumman – Huntsville, Alabama
- Raytheon – Huntsville, Alabama, and Andover, Massachusetts
- Lockheed Martin – Dallas, Texas

Activity

- In July through September 2020, the Army executed LUT II at White Sands Missile Range, New Mexico, in accordance with a DOT&E-approved test plan. The LUT consisted of five phases:
  - Software and hardware-in-the-loop sustained operations against simulated threats
  - Sustained operations against live air targets
  - Two missile flight tests
  - March order and emplacement
  - Adversarial assessment
- Coronavirus (COVID-19) pandemic travel restrictions delayed the LUT by 2 months and prevented DOT&E from observing the test.
- The Army conducted a Milestone C decision in November 2020.
- DOT&E published a classified report in November 2020 to inform the Milestone C decision.

Assessment

- Preliminary analysis indicates the AIAMD system demonstrated better software stability and hardware reliability compared to the 2016 LUT.
- Deficiencies in the Flight Mission Simulator/Digital and Launcher on the Net tools, used to simulate Patriot radars and launchers, are causing problems which degrade the ability to adequately assess system effectiveness. The Army is working with the vendors to correct them prior to IOT&E.
- The Single Integrated Air Picture was inconsistent across the EOCs in some of the LUT events. Analysis is ongoing.

Recommendation

1. The Army should conduct an adequate verification, validation, and accreditation of all modeling and simulation planned for use in the IOT&E.

Army Tactical Wheeled Vehicles

FMTV
(Family of Medium Tactical Vehicles)

JLTV
(Joint Light Tactical Vehicle)
Close Combat Weapons carrier

JLTV
(Joint Light Tactical Vehicle)
General Purpose

JLTV
(Joint Light Tactical Vehicle)
Utility/M119A3 Howitzer

JLTV
(Joint Light Tactical Vehicle)
Heavy Guns Carrier

Executive Summary

- The Family of Medium Tactical Vehicles (FMTV) A2 variants have demonstrated poor reliability and degraded vehicle functionality in developmental testing. The program has taken extensive actions to require the vendor to conduct failure analysis and perform corrective actions to improve the FMTV A2 reliability.
- The Joint Light Tactical Vehicle (JLTV) program canceled the May 2020 developmental test with soldiers due to the coronavirus (COVID-19) pandemic and soldier availability during the pandemic. The purpose of the testing was to provide soldiers' assessment of the command, control, and communication capability of the Mounted Family of Computer Systems (MFoCS) integrated on the JLTV. DOT&E plans to assess the MFoCS capabilities during the August 2021 JLTV developmental/operational testing (DT/OT).

System

FMTV

- The FMTV A1P2 Underbody Armor Kit (UAK) is a survivability upgrade to the currently fielded FMTV A1.
- The FMTV A2 is a set of hardware and software improvements to the FMTV A1 trucks designed to expand the capabilities of the FMTV. These upgrades include: adjustable suspension system, increased payload, improved

ride quality, electronic stability control, and an underbody protection kit.
- The FMTV A2 Family of Vehicles (FoV) consists of the following light and medium variants that operate on- and off-road.
  - The Light Medium Tactical Vehicle (LMTV) transports a 6,000-pound payload and a 12,000-pound towed load.
  - The Medium Tactical Vehicle (MTV) transports a 16,000-pound payload and a 21,000-pound towed load.

JLTV
- The JLTV FoV is the partial replacement for the High Mobility Multipurpose Wheeled Vehicle (HMMWV) fleet for the Army, Marine Corps, and Air Force. The Services intend the JLTV to provide increased crew protection against IEDs and underbody attacks, improved mobility, and higher reliability than the HMMWV.
- The JLTV FoV consists of two mission categories: the JLTV Combat Tactical Vehicle, designed to seat four passengers, and the JLTV Combat Support Vehicle, designed to seat two passengers.
- The JLTV Combat Tactical Vehicle has a 3,500-pound payload and three mission package configurations:
  - General Purpose Variant
  - Heavy Guns Carrier Variant
  - Close Combat Weapon Carrier Variant
- The JLTV Combat Support Vehicle has a 5,100-pound payload and one mission package configuration:
  - Utility (UTIL) Prime Mover Variant that can accept a Troop Seat Kit to carry up to eight soldiers or a cargo shelter

Mission

FMTV
- The Army employs the FMTV FoV to provide multi-purpose transportation in maneuver, maneuver support, and sustainment units. Transportation units conduct line and local haul missions carrying cargo and soldiers with the LMTV and MTV Cargo variants and associated trailers. Medical units employ the MTV – Load Handling System to transport, load, and off-load medical containers. Maintenance units use the MTV wrecker to conduct recovery operations of light- and medium-wheeled vehicles. Engineering units employ the MTV Dump Truck to haul and dump material.

JLTV
- Army and Marine Commanders employ units equipped with JLTV as a tactical-wheeled vehicle to support all types of military operations. Airborne, air assault, amphibious, light, Stryker, and heavy forces use JLTVs as reconnaissance, maneuver, and maneuver sustainment platforms. Air Force units intend to employ JLTVs for security and special operations.
- Small ground combat units will employ JLTV in combat patrols, raids, long-range reconnaissance, and convoy escort.

Major Contractors

FMTV
- Oshkosh Corporation – Oshkosh, Wisconsin

JLTV
- Oshkosh Corporation – Oshkosh, Wisconsin

Activity

FMTV
- In FY20, the program developed the FMTV A2 Test and Evaluation Master Plan (TEMP) Annex to outline the Production Verification Test (PVT) and FOT&E for the FMTV A2 FoV. The program plans to submit the FMTV A2 TEMP Annex for DOT&E approval in 3QFY21.
- In December 2019, the Army completed the FMTV A2 LFT&E program. LFT&E for FMTV A1P2 was delayed due to COVID-19 restrictions to access test facilities. Testing resumed in August 2020 and will be completed in 1QFY21. DOT&E will publish a combined LFT&E report detailing the survivability of both the FMTV A2 and FMTV A1P2 in 2QFY21. The Army executed the LFT&E in accordance with DOT&E-approved test plans.
- The Army Test and Evaluation Command (ATEC) plans to conduct the FMTV A2 FOT&E during 2QFY22.

JLTV
- In FY20, ATEC executed the JLTV A1 Production Verification Testing (PVT) at Aberdeen Proving Ground, Maryland, and Yuma Proving Ground, Arizona.
- The program canceled the May 2020 developmental test with soldiers due to COVID-19 and soldier availability during the pandemic. The purpose of the testing was to obtain soldiers' assessment of the command, control, and communication capability of the MFoCS integrated on the JLTV.
- Fielding of JLTVs to several Army units was delayed approximately 3 to 7 months due to COVID-19.
- In August 2020, the program conducted a Soldier Touchpoint event at Fort Polk, Louisiana, to inform the design and production of the JLTV Fire Direction Center (FDC) Integration Kit and M119A3 Howitzer interface. ATEC plans to conduct DT/OT of this artillery integration in August 2021 at Fort Campbell, Kentucky.
- The program plans to conduct the JLTV Close Combat Weapon Carrier Soldier Touchpoint event at Fort Benning, Georgia, in January 2021, to demonstrate fixes to the vehicle with respect to firing tube-launched, optically tracked, wireless-guided (TOW)/Saber weapons from the rear of vehicle, missile rack configuration, and missile

reloads. These fixes address findings from the 2018 JLTV Multi-Service Operational Test and Evaluation and developmental testing.

Assessment

FMTV

- The FMTV A2 variants have demonstrated poor reliability and degraded vehicle functionality based on developmental testing. The variants experienced several failure modes during reliability testing: suspension leveling and sway bar, coolant and engine leaks, sensor and hydraulic systems, Drive Display Unit and sensors, and stuck doors.
- In FY20, the program required the vendor to conduct failure analysis and perform corrective actions to improve the FMTV A2 reliability. The FMTV A2 may require a reliability growth program and necessitate a redesign in order to meet variant reliability requirements. The Army may need to reassess the FMTV A2 required reliability without a successful reliability growth plan and potential design modifications.
- Preliminary assessments indicate that the FMTV A2 is meeting its survivability requirements.
- The survivability assessment of the FMTV A1P2 is ongoing and the initial analyses demonstrated the expected performance of the underbody kit.
- The Army delayed the FMTV A2 FOT&E by 6 months due to performance and reliability failures demonstrated during developmental testing. This delay may not provide sufficient time for the program to fix FMTV A2 failures, complete performance testing, and verify the FMTV A2 variants met reliability requirements prior to the FOT&E.

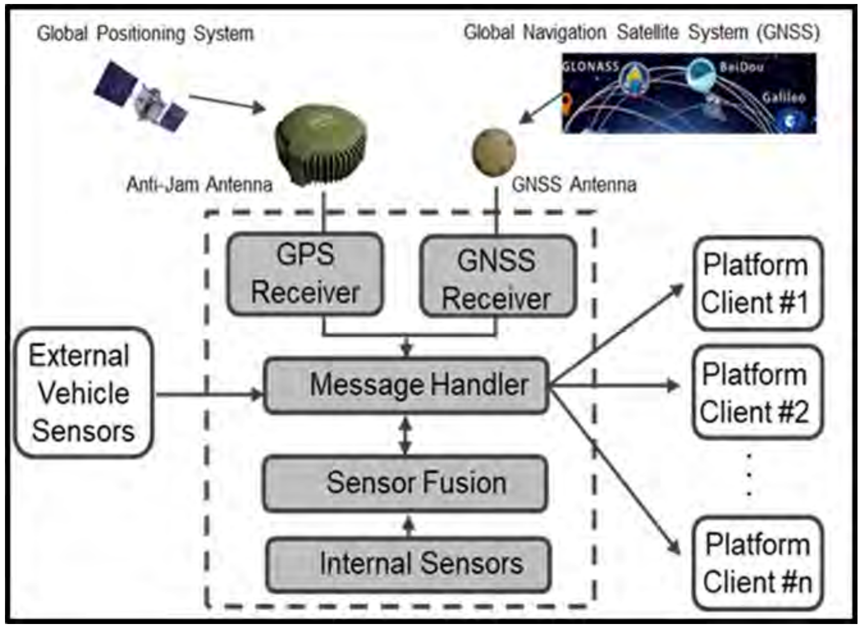
JLTV

- The JLTV A1 exceeded its reliability requirement of 2,400 mean miles between operational mission failures during the 36,000-mile production verification testing (PVT). Oshkosh Field Service Representatives (FSRs) performed maintenance demonstrating a mean time to repair (MTTR) of approximately 0.69 hours. This maintainability time is an improvement over the 1-hour average time to repair demonstrated during the last phase of developmental testing. The JLTV has not met its MTTR requirement of 0.5 hours for field level maintenance tasks performed by the military maintainer.
- The PVT confirmed the improvements to reduction in the external vehicle noise with the addition of a muffler, upgraded alternator, and isolators. The integration of new gears provided marginal improvement to external vehicle noise.
- During the Soldier Touchpoint event, field artillery soldiers assessed the JLTV UTIL FDC Kit and the interface as the M119A3 prime mover. The event did not include soldiers using the FDC to execute notional fire missions from the FDC to the M119A3. The program plans to address soldier recommended modifications to the JLTV UTIL prior to the JLTV DT/OT.
    - The JLTV UTIL had sufficient ammo carry capability and good ride quality while on the move.
    - Placement of mission equipment to improve storage and use by soldiers.
    - Compared to the HMMWV's tailgate, soldiers assessed the JLTV tailgate as deficient for use as a ready rack for projectiles and fuses in preparation for firing due to its smaller dimensions and light weight.
    - Relocate the power cable between the JLTV and the Howitzer to the same side of the vehicle as the HMMWV to avoid the cable interfering with crew tasks.

Recommendations

1. The FMTV program should develop a plan to correct and verify fixes to failures discovered during performance and reliability testing to the FMTV variants restarting developmental testing prior to the FOT&E.
2. The Army should assess the command, control, and communication capability of the JLTV integrated with the MFoCS during the August 2021 DT/OT.

Assured — Positioning, Navigation, & Timing (Assured – PNT)



Executive Summary

- In 2019, the Commanding General, Army Futures Command issued individual Directed Requirements (DR) for the Dismounted Assured Positioning, Navigation, and Timing (A-PNT) System (DAPS), the Mounted A-PNT System (MAPS), and Alternative Navigation (ALTNAV) programs, directing the rapid prototyping, operational assessment, and limited fielding of advanced PNT technologies. The DRs outlined a "buy, try, and decide" process to inform an enduring requirement and follow-on programs of record.
- Throughout FY19 and FY20, the Army Test and Evaluation Command (ATEC) and Program Manager (PM) PNT conducted several test-fix-test cycles with each of the MAPS, DAPS, and ALTNAV solutions, supporting selection to phases I, II, and III of the prototyping efforts.
- In August 2020, the Army conducted the MAPS Operational Technical Demonstration (OTD) with the MAPS Generation (GEN) I.X and GEN II systems at White Sands Missile Range, New Mexico. Following this test, the MAPS GEN II system provided by Collins Aerospace was selected to enter production maturation under phase III of the Other Transaction Authority (OTA) contract.

System

- PM PNT is developing technology and fielding A-PNT products that are intended to provide the Army ground maneuver forces with access to trusted PNT information (PNT-I) under conditions where GPS signals may be degraded or denied.
- A-PNT products improve the soldier's ability to determine the validity and accuracy of their PNT-I.
- A-PNT consists of four primary products:
  - MAPS – Vehicle-mounted system providing PNT-I to multiple onboard client systems.
  - DAPS – Soldier-worn system providing PNT-I to Nett Warrior for dismounted operations.
  - PNT Modernization – Transitioning alternative and complementary PNT technologies for integration into MAPS and DAPS systems. The first ALTNAV-capable product is identified as DAPS GEN 1.1.
  - Resiliency and Software Assurance Measures – Software upgrades to legacy military GPS receivers.
- PM PNT is supporting the Army's transition to Military-Code GPS through the integration of Military GPS User Equipment in the MAPS and DAPS.

Mission

- A unit equipped with MAPS or DAPS will use their trusted PNT-I to conduct operations in conditions that impede or deny access to GPS signals, such as operations in dense vegetation, built-up urban and mountainous terrain, and in the presence of electromagnetic interference or enemy jamming and spoofing of the GPS.
- A-PNT directly enables positioning of forces; navigation across the operational environment; communication networks; situational awareness applications; and protection, surveillance, targeting, and engagement systems that contribute to combined arms maneuver.
- A-PNT supports Army multi-domain operations by mitigating the impacts of anti-access/area denial capabilities, allowing synchronized maneuver and precision fires from tactical, operational, and strategic distances in order to close with and destroy enemy forces with sufficient combat power, tempo, and momentum.

Major Contractors

- DAPS GEN 1.0
  - Integrated Solutions for Systems, Inc. (IS4S) – Auburn, Alabama
  - L3 Harris Technologies, Inc. – Anaheim, California
  - Mayflower Communications Company – Bedford, Massachusetts

- ALTNAV (DAPS GEN 1.1)
  - NAL Research Corporation – Manassas, Virginia
- MAPS GEN I and GEN I.X
  - GPS Source Inc. subsidiary of General Dynamics Mission Systems – Colorado Springs, Colorado
- MAPS GEN II
  - Collins Aerospace subsidiary of Raytheon Technologies – Cedar Rapids, Iowa

---

Activity

- In 2019, the Commanding General, Army Futures Command issued individual DRs for the DAPS, MAPS, and ALTNAV programs, directing the rapid prototyping, operational assessment, and limited fielding of advanced PNT technologies. The DRs outline a "buy, try, and decide" process to inform an enduring requirement and follow-on programs of record.
- The Army PM PNT is utilizing several OTA contracts and a phased prototyping approach to satisfy the DRs and ensure the Army is selecting the best vendor solutions available. In FY19, OTA contracts were extended to one ALTNAV, three DAPS GEN 1.0, and three MAPS GEN II vendors. This is in addition to an existing MAPS GEN I contract.
- Following FY19 testing, the MAPS program selected Collins Aerospace to move into phase II of the MAPS GEN II prototyping effort. To enhance competition during phase II, GPS Source partnered with L3 Harris Technologies and was invited to compete with their GEN I.X system.
- Throughout FY20, ATEC and PM PNT conducted several test-fix-test cycles with each of the MAPS, DAPS, and ALTNAV solutions to support future invitations to the next prototyping phases. This testing included chamber testing, systems integration lab testing, and open-air range testing.
- In August 2020, the Army conducted the MAPS OTD with the MAPS GEN I.X and GEN II systems at White Sands Missile Range, New Mexico. The OTD supported selection for phase III, product maturation, of the OTA contract. Since this test was conducted under the DR prototyping effort, the Army did not develop an operational test plan for DOT&E approval. Following the OTD, the MAPS program selected Collins Aerospace to move into prototyping phase III.
- The MAPS and DAPS programs were able to mitigate several coronavirus (COVID-19) pandemic test impacts and maintain their acquisition timelines. DOT&E was not able to observe the MAPS OTD due to COVID-19 restrictions.

Assessment

- Early testing of MAPS and DAPS prototypes revealed that software that fuses the GPS and other sensor inputs was not mature. Testing in late FY20 indicated improvement and PM PNT intends to address software maturity in upcoming test-fix-test cycles and prior to entering program of record status at Milestone C.
- MAPS will replace the existing GPS receivers and antennas in most of the Army's ground vehicle variants. The program is initially focusing on the tactical and combat vehicles variants that would be part of the Brigade Combat Teams supporting early entry phases of a conflict. Within these vehicles, there are approximately 30 client system variants that MAPS must interface with. Integration testing in FY19 and FY20 revealed that adhering to the GPS interface standard does not guarantee compatibility and software updates to the client systems will be necessary. Extensive integration engineering and testing is planned for FY21-23.
- ATEC and PM PNT conducted the MAPS and DAPS open-air testing in threat-realistic, GPS-contested environments, utilizing soldier operators to gain early user feedback. Due to the focus on selecting the best vendor solution and the complexity of integrating with the numerous vehicle and client variants, the MAPS open-air testing has been limited to Stryker vehicles and a few key client systems. Because of the limited integration, the test team has not yet been able to use a mission-based test design.
- DOT&E will be receiving and analyzing the test data from the MAPS OTD and late FY20 DAPS testing in order to gain insights into prototype system performance.

Recommendation

1. The Army should ensure that future open-air range testing includes the following:
   - A broader set of platforms and PNT-dependent client systems to confirm that integration problems not identified in systems integration lab and chamber testing are discovered as early as possible.
   - A mission-based testing design to ensure a cross-section of PNT-dependent missions and tasks are examined under operational conditions ahead of planned IOT&E events.

Bradley Engineering Change Proposal (ECP) and Modernization

Executive Summary

- In 2020, the Army completed the cooperative vulnerability and penetration assessment (CVPA) (January 2020), the adversarial assessment (AA) (September – October 2020), and the FOT&E (October 2020) in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP).
- The Army Test and Evaluation Command (ATEC) suspended the maneuver portion of the FOT&E during record run five due to safety concerns. The turret batteries overheated in all six test articles creating a safety hazard to soldiers.
- DOT&E has sufficient data to inform an evaluation by merging the authenticated pilot test data and the record test data.
- DOT&E plans to publish an operational and live fire test report in 2QFY21 to support the program's scheduled Materiel Release decision in 3QFY21.

System

- The Bradley Engineering Change Proposal (ECP) program integrates new technologies to mitigate the degradation of legacy system performance and to maintain the operational capability outlined in current system requirements documents
  - ECP Phase I included a suspension and track upgrade to restore ground clearance and suspension reliability because of increases in Bradley armor and weight.
  - ECP Phase II will upgrade the electrical system and power train to restore lost mobility, and integrate new technologies to improve situational awareness and vehicle survivability.
- Completion of Phases I and II will result in the conversion of existing M2A3 and Operation Desert Storm – Situational Awareness (ODS-SA) versions of Bradley Fighting Vehicles into the M2A4 version, and the conversion of M7A3 Bradley Fire Support Team vehicles into the M7A4 version. The current plan is to field the M2A4 and M7A4 to four brigades including one brigade set to support the European Deterrence Initiative.
- The A4 versions will inherit the survivability enhancement features found on the A3/ODS-SA baseline configurations: Bradley Urban Survivability Kits, Bradley Reactive Armor Tiles, and Add-on Armor Kit that the Army developed and fielded in response to Operational Needs Statements during Operation Iraqi Freedom. The A4 will include the Commander's Independent Viewer.

Mission

Combatant Commanders employ Armor Brigade Combat Teams equipped with Bradley Family of Vehicles to provide protected transport of soldiers, to provide direct fires to support dismounted infantry, to disrupt or destroy enemy military forces, and to control land areas.

Major Contractor

BAE Systems Land and Armaments – York, Pennsylvania

Activity

- DOT&E approved an updated TEMP including a LFT&E Strategy in July 2020.
- The coronavirus (COVID-19) pandemic affected the FOT&E schedule, delaying a gunnery event by 4 weeks to November 2020.
- In FY20, the Army conducted the CVPA at Yuma Proving Ground, Arizona, and the AA and FOT&E at Fort Hood, Texas. The Army accomplished most of the planned test objectives during the suspended FOT&E.
- ATEC used a mechanized infantry platoon (4x M2A4), a Company Fire Support Element (1x M7A4), and a Company Headquarters Section (1x M2A4) as the test unit, with one M2A4 and one M7A4 as cybersecurity test vehicles and spares. The test unit executed 6 offensive missions with a

total of 18 battle tasks against an opposing force mechanized infantry platoon and scout section.

- The FOT&E deviated from the approved test plan. ATEC suspended the maneuver portion of the FOT&E during record run five due to safety concerns. DOT&E has sufficient data to inform an evaluation by merging the authenticated pilot test data and the record test data.
- All six test article turret batteries overheated and discharged toxic fumes into the turret and crew compartment. This is a safety hazard to soldiers. The program manager was present during test and observed the turret battery issue. He supported the recommendation to suspend the remaining maneuver missions.
- The Army is delaying the gunnery event until the turret battery issue is resolved and tested.
- In FY19, the Army completed the Phase I Bradley ECP LFT&E program using prototype vehicles. Phase II, scheduled to be completed in February 2021, will include full-up system-level testing using a production-representative vehicle.

Assessment

- DOT&E is analyzing the test data to assess M2A4/M7A4 effectiveness, suitability, and survivability.
- Preliminary assessment of live fire test data indicate that upgrades incorporated by the Bradley ECP program did not introduce any significant or unexpected vulnerabilities.
- DOT&E plans to publish an operational and live fire test report in 2QFY21 to support the scheduled Materiel Release decision in 3QFY21.

Recommendations

1. The Army should examine the risk created by issues with the turret batteries and adjust the Materiel Release decision date.
2. The program manager should conduct root cause analysis and correct the turret battery overheating and the toxic fumes in the turret and crew compartment before fielding to soldiers.

CH-47F Block II Chinook

Executive Summary

- The Army plans to execute the CH-47F Block II Limited User Test (LUT) in 3QFY21.
- The Program Office has been using three CH-47F Block II Engineering Development Model aircraft as test platforms. The Program Office has used a System Integration Laboratory (SIL) for software testing and a ground test vehicle (GTV) for dynamic testing of aircraft components.
- The CH-47F Block II completed a total of 387 developmental flight testing hours in FY20.
- The most recent Advanced Chinook Rotor Blade (ACRB) design is meeting increased power requirements during both in and out of ground effect hover testing. The ACRBs demonstrated a 2,300-pound increase at 95 degrees, 4,000 feet pressure altitude. This ACRB is producing excessive vibrations in various flight profiles across the Block II's performance envelope. Aircrews reported prolonged fatigue and other physiological conditions due to excessive vibrations.
- The CH-47 Block II LFT&E program is behind schedule. Design changes needed to correct performance deficiencies, parts availability, and the availability of a specialized test facility will delay multiple live fire test events until after Milestone C.
- The redesigned Block II fuel cell failed the Phase II qualification testing and the fuel system contractor must redesign and manufacture a new fuel cell for qualification prior to future live fire evaluation of the fuel systems.

System

- The CH-47F is a twin-turbine, tandem-rotor, heavy-lift transport helicopter designed to transport 31 combat troops, artillery, and equipment up to 16,000 pounds.
- General Support Aviation Battalions assigned to Combat Aviation Brigades use the CH-47F to support operational requirements across the battlespace. Each Combat Aviation Brigade is authorized 12 CH-47F helicopters.
- The CH-47F Block II is a modernization of the CH-47F Block I. The CH-47F Block II is a consolidation of post-production modifications made on CH-47F Block I production aircraft as well as new advancements unique to the CH-47F Block II.
- Major system improvements include:
  - Reduced weight ballistic protection system
  - Redesigned flight control system; Digital Automatic Flight Control System (DAFCS)
  - Upgraded drive train system; Improved Drive Train (IDT)
  - New rotor blade design; ACRB
  - Redesigned fuel system; Lightweight Fuel System (LFS)
  - Updated Common Avionics Architecture System (CAAS)
- The Army's objective is to purchase 464 CH-47F aircraft.

Mission

The CH-47F Block II supports the Army's requirement for a heavy lift helicopter to execute full spectrum operations. A unit equipped with the Chinook provides heavy lift capability to accomplish critical tasks across the operational environment including air assault, air movement, causality evacuation, aerial recovery, and area resupply. The Chinook's range, speed, and lift capacity allows for operational flexibility. Depending on mission requirements, the CH-47F can be employed individually, in multi-ship formations, or as a company.

Major Contractors

- Aircraft: Boeing Helicopter Company – Ridley Park, Pennsylvania
- Software: Rockwell Collins – Cedar Rapids, Iowa
- Fuel System: Meggitt Polymers and Composites – Rockmart, Georgia

Activity

- The CH-47F Block II program has conducted all testing in accordance with the DOT&E-approved Test and Evaluation Master Plan to include the LFT&E Strategy.
- The coronavirus (COVID-19) pandemic has had a minor effect on the CH-47F Block II program. The Program Office adjusted some test events, but the overall program schedule has not been affected.
- The Program Office has been using three CH-47F Block II Engineering Development Model aircraft as primary test assets, which include all Block II modifications. The program has been using the SIL to support software testing, and a GTV to support dynamic testing of aircraft components.
- The CH-47F Block II completed a total of 387 developmental flight testing hours in FY20.
- The CH-47F Block II Program Office has tested the aircraft across the flight envelope to understand the performance of the improved drive train, the new ACRB, redesigned rotor assembly, and numerous structural changes. The aerodynamic effects of these design changes vary across the Block II's flight envelope.
- Previously, the Army conducted the following testing in accordance with the LF strategy.
  - In FY18, the Army performed the following testing:
    - Qualification and live fire testing of two versions of lighter-weight Cargo On/Off Loading System (COOLS) integrated floor armor. The lightest-weight armor was designed to match the performance of the currently fielded armor, while the other armor was designed to defeat a more energetic threat.
    - Ballistic testing of static segments of the ACRB to characterize the type and extent of damage caused by combat representative threats. The Army plans to begin quasi-static testing of ACRB segments under representative loads in March 2021. The Army will develop detailed test plans for dynamic blade testing on the GTV in FY21 based upon the results of the quasi-static tests.
  - In FY19, the Army conducted ballistic testing of the Ferrium® C61™ steel increased strength rotor shaft test coupons.
- In December 2019, the Army conducted ballistic testing of the rotor pitch control links for both Block I and Block II CH-47F configurations.
- In August 2020, the contractor executed Phase II qualification testing of the new fuel cell design.
- In coordination with DOT&E, the Army completed the live fire test plan to evaluate the drive shaft vulnerabilities to kinetic threats. Testing is scheduled to start in 1QFY21.
- In July 2020, in coordination with the Common Infrared Countermeasures (CIRCM) program, the Program Office supported the developmental testing of CIRCM, the Army's next generation of aircraft survivability equipment. For more information on the CIRCM program, see the article on page 75.
- In August 2020, the CH-47F Program Office completed a cooperative vulnerability identification event intended to identify potential cybersecurity attack vectors to be explored during the cooperative vulnerability and penetration assessment scheduled in conjunction with the CH-47F Block II LUT in 3QFY21.

Assessment

- The ACRB has undergone multiple redesigns during developmental testing of the CH-47F.
  - The initial ARCB designs were stable but did not provide the power improvements predicted by computational models.
  - The most recent ACRB design is meeting increased power requirements during both in and out of ground effect hover testing. The ACRBs demonstrated a 2,300 pound increase at 95 degrees, 4,000 feet pressure altitude environmental conditions compared to the legacy CH-47F fiberglass rotor blades.
  - The most recent ACRB design produces excessive vibrations in ground, hover, and forward flight that may cause a safety of flight risk. Aircrews reported prolonged fatigue and other physiological conditions due to excessive vibrations following a developmental test flight using the redesigned ACRB's. The Program Office is examining the issue and determining the potential effect of the program's LUT in 3QFY21.
- Both weights of the COOLS armor performed better than the original COOLS armor, and both outperform the CH-47F design specification.
- Preliminary analysis indicates that rotor shaft and pitch control links provide at least equivalent resistance to kinetic threats as the legacy hardware.
- The fuel cell failed to self-seal during Phase II qualification testing and the sponson sustained substantial damage. The CH-47F fuel system contractor needs to redesign and requalify the fuel cell and the sponson needs to be repaired prior to any live fire testing of the fuel system on the ballistics fuselage test article.
- The GTV incurred structural damage during dynamic drive train testing. Unless adequately repaired, this may limit the extent of the dynamic ballistic testing of the ACRB blades.
- The LFT&E program is behind schedule due to design changes to correct performance deficiencies, parts manufacturing and availability, and specialized contractor test facility availability:
  - Required fatigue and dynamic GTV testing of the ACRB will not be complete until after Milestone C (April 2021).
  - Engine fire suppression system testing is not currently scheduled but is expected after Milestone C.
  - Dry bay fire testing is not currently scheduled.
- Combined with the results of fuel cell qualification testing, the delay of several live fire tests until after Milestone C increases program risk.

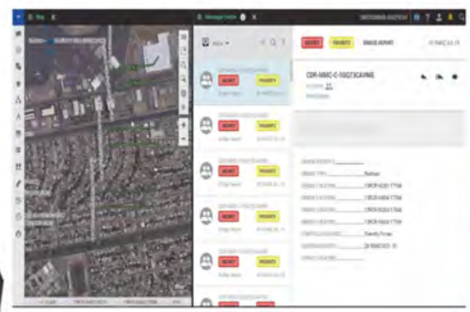
Recommendations

The Program Office should:

1. Determine the root cause of ARCB-related aircraft vibrations and make any necessary changes to the blade or aircraft design.
2. Complete the approved LFT&E program in a timely fashion so all required data are available for continued program development.
3. Implement the necessary design changes to the fuel cell and sponson and requalify the design prior to live fire testing on the GTV.

Command Post Computing Environment (CPCE)

Tactical Server Infrastructure (TSI) Version 2(a) - Small



Command Post Computing Environment (CPCE) Software

Tactical Server Infrastructure (TSI) Version 2(a) - Large

Executive Summary

- In November 2019, the Army conducted a Program Executive Office Command, Control, Communications – Tactical (PEO C3T) Acquisition Decision Memorandum (ADM)-directed, program-led developmental performance test to verify correction of deficiencies noted during the 2018 Command Post Computing Environment (CPCE) Increment 0 IOT&E. The results of the lab-based event demonstrated:
  - CPCE has improved in message handling, map services, availability, chat message management, and a reduced traffic load on tactical networks.
  - CPCE's scalability does not support the intended number of users and translation of Command and Control message data results in significant latency.
  - When under stress, CPCE can discontinue generating outbound server data for logged in users.
- The Army is planning for a June – July 2021 CPCE Increment 1 operational test and working to resolve challenges related to integrated testing, data instrumentation, and cybersecurity assessments. The Army presented its initial strategy for completing an adequate CPCE Increment 1 operational test in an Early Concept Brief to DOT&E in October 2020.

System

- The CPCE is a server-based software system that provides mission command applications to support commanders and staff using general-purpose client computers, located within battalion through corps Tactical Operations Centers. The Army intends CPCE to provide soldiers a common operating picture, shared situational awareness, collaboration tools, and Command and Control messaging.
- CPCE provides basic mission command applications required in tactical command posts as part of the Army's Common Operating Environment (COE). The Army designed CPCE to interface with other developing COE Computing Environments (CEs), and to interoperate with joint, allied, and coalition forces.
- The Army is developing CPCE in increments as an evolution of existing, stove-piped mission command systems to a common, shared client-server architecture.
- The Army designed and fielded CPCE Increment 0 (formerly version 3.0) to replace and integrate the capabilities of the following existing mission command systems:
  - Command Post of the Future
  - Tactical Ground Reporting System
  - Command Web
  - Global Command and Control System – Army
- The Army is developing CPCE Increment 1 to provide increased functionality in accordance with an incremental development strategy, and improve the performance of Increment 0, through features such as:
  - Significant Activities (SigActs) Tracking Capability
  - Geospatial Tool Persistence on Map
  - Server Status Monitoring Tools
  - Increased Consumption of External Data (e.g. Electronic Warfare, Cyber, Fires data)

Mission

The Army intends for commanders and staff at battalion through corps level to use CPCE to conduct mission command throughout all phases of the Army operations process, to include planning, preparation, execution, and continuous assessment of unit missions. As COE CEs are developed, units will use CPCE as a collection point for data from sensors, aviation, logistics, fires, intelligence, and safety information, including mounted, dismounted, and home station command units.

Major Contractors

- Weapons Software Engineering Center – Picatinny Arsenal, New Jersey
- Systematic USA/Systematic AS – Centreville, Virginia/ Aarhus, Denmark

Activity

- In July 2019, the PEO C3T, as the Milestone Decision Authority (MDA), published a CPCE Increment 0 ADM that:
  - Authorized a conditional full deployment of CPCE Increment 0 to two divisions, two brigade combat teams, and Defender 2020 exercise participants
  - Recognized DOT&E's November 2018 CPCE IOT&E assessment of not effective, not suitable, and not survivable
  - Detailed Army test and DevOps events, highlighting enhancements since the CPCE IOT&E
  - Directed Program Manager, Mission Command (PM, MC) to conduct a lab-based, developmental performance test to demonstrate fixes for effectiveness and suitability deficiencies noted during the CPCE Increment 0 IOT&E
- During October – November 2019, PM, MC with the support of Army Test and Evaluation Command (ATEC) conducted the ADM-directed CPCE developmental performance test at Aberdeen Proving Ground, Maryland. DOT&E and ATEC briefed the test results to the PEO C3T MDA in February 2020.
- In May 2020, the PEO C3T, as the MDA, published an amendment to the CPCE Increment 0 ADM that removed conditional full deployment of CPCE Increment 0.
- The Army is planning a CPCE Increment 1 Operational Test in June – July 2021, using the Joint Warfighting Assessment 21 (JWA21) as the test event. JWA21 is a worldwide mission command exercise, with the CPCE test portion planned for Fort Carson, Colorado.

Assessment

- In November 2019, the PM MC completed the ADM-directed CPCE Increment 0 developmental performance test, and demonstrated the following results compared to the 2018 CPCE IOT&E:
  - CPCE's message handling has improved in both timeliness and accuracy.
  - CPCE's map service and overall availability showed improvement.
  - CPCE's ability to manage chat messages has improved, along with a reduction in the quantity of distracting automated chat messages.
  - CPCE's ability to handle network load is better than demonstrated at IOT&E, yet still requires buffering at peak periods for a typical brigade.
  - Under stress, CPCE can discontinue generating outbound server data for logged in users.
  - CPCE's scalability is not sufficient for the number of intended users.
  - CPCE's Command and Control message data translation results in significant latency and does not generate situational awareness in a reliable manner.
  - CPCE's graphics support capabilities can result in inaccuracies on the displayed common operational picture. The program plans to correct the demonstrated deficiencies with the release of CPCE Increment 1.
- The Army continues to develop a CPCE Increment 1 integrated testing strategy to result in an operational test at the June – July 2021 JWA21. With the termination of the Army's annual Network Integration Evaluation events, the Army is working to overcome challenges of integrated testing, data instrumentation, and cybersecurity assessments. The Army presented its initial strategy for completing an adequate CPCE Increment 1 operational test in an Early Concept Brief to DOT&E in October 2020.

Recommendations

The Army should:

1. Continue to improve CPCE Increment 0 hardware and software to address lingering IOT&E shortcomings and problems discovered at the November 2019 ADM-directed developmental performance test.
2. Complete development, resourcing, approval, and execution of the CPCE Increment 1 operational test.

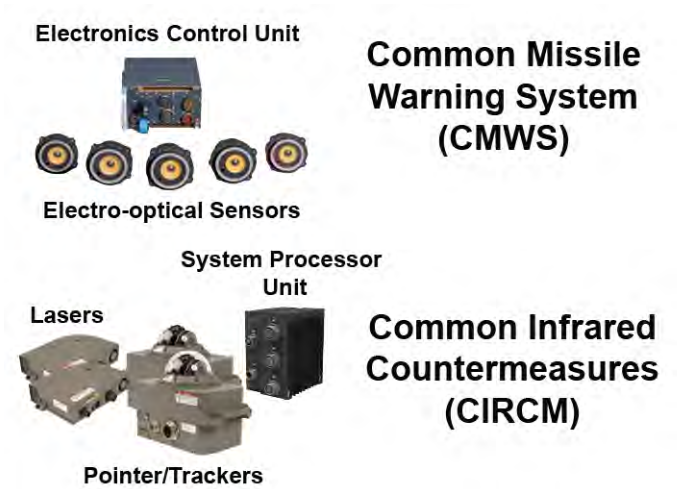
Common Infrared Countermeasures (CIRCM)

Executive Summary

- The Army Test and Evaluation Command (ATEC) conducted an IOT&E of the Common Infrared Countermeasures (CIRCM) system as integrated on the UH-60M Black Hawk at multiple facilities and open-air locations from February through November 2019. Testing supports a decision in March 2021 to proceed to full-rate production and authorize up to 596 units. DOT&E produced a classified report to support that decision.
- Operational testing showed the system is effective against man-portable air-defense systems (MANPADS) and is suitable – though the human-system interface design needs improvement. Cybersecurity testing demonstrated the system has minor vulnerabilities the Army can mitigate.

System

- The CIRCM system is a defensive system for aircraft, which is designed to defend against surface-to-air infrared missile threats.
- The system of systems combines the Army's legacy Common Missile Warning System (CMWS) consisting of ultraviolet missile warning sensors and an electronics control unit or other Missile Warning Systems (MWSs) with the CIRCM system consisting of two lasers, two pointer/trackers, and a system processor unit.
- If the MWS detects a probable threat to the aircraft, it passes the tracking information for that possible threat to the CIRCM processor, which directs the pointer/trackers to slew to and jam the threat with laser energy. Simultaneously, the MWS processor continues to evaluate the possible threat to determine if it is a real threat or a false alarm. If the MWS declares the detection to be an actual threat, it notifies the aircrew through audio alerts and a visual display on the aircraft Multi-Function Display in the cockpit, while also releasing flares as a countermeasure.



Mission

- Commanders employ Army rotorcraft equipped with the CIRCM system to conduct air assaults, air movements, casualty evacuation, attack, armed escort, reconnaissance, and security operations.
- During Army missions, the CIRCM system is intended to provide automatic protection for rotary-wing aircraft against shoulder-fired and vehicle-launched infrared surface-to-air missiles.

Major Contractor

Northrop Grumman, Electronic Systems, Defensive Systems Division – Rolling Meadows, Illinois

Activity

- ATEC conducted IOT&E of the CIRCM system as integrated on the UH-60M Black Hawk from February through November 2019. Testing supports a decision in March 2021 to proceed to full-rate production and authorize up to 596 units. DOT&E produced a classified report to support that decision.
- Testing incorporated hardware-in-the-loop activities from the Integrated Threat Warning Laboratory located at Wright Patterson AFB, Ohio; the Threat Signal Processor-in-the-Loop facility located at Naval Air Weapons Center China Lake, California; and the Guided Weapons Evaluation Facility located at Eglin AFB, Florida.
- Flight testing occurred at multiple locations throughout the United States to subject the system to the following environments: heavy foliage, littoral, mountainous, snowy, and urban and industrial infrared and ultraviolet clutter.
- ATEC primarily accomplished testing in accordance with DOT&E-approved test plans.
- The Army has instituted workarounds and is developing a solution for the occasional CIRCM tracker jitter problem caused by electromagnetic interference introduced by sources on the UH-60M aircraft.

- The coronavirus pandemic caused delays in data analysis and reporting due to personnel having limited access to systems necessary to process classified data and related information.

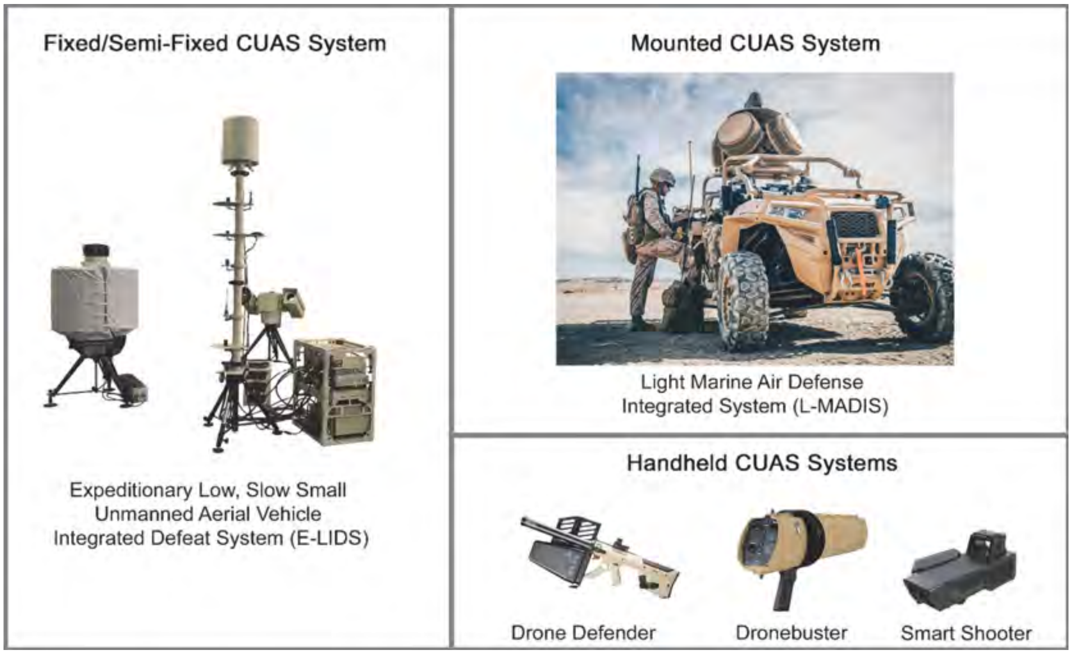
Assessment

- Operational testing showed the system is effective against MANPADS and vehicle-launched infrared surface-to-air missiles. Testing also showed the system has acceptable reliability, availability, maintainability, and built-in test performance.
- Electromagnetic interference introduced by sources on the UH-60M aircraft caused jitter in CIRCM's tracker, which could reduce jamming power placed on the threat and may cause the CIRCM system to restart.
- The CIRCM control panel has poor control switch placement in the cockpit that makes it difficult for the pilots to access. The Army is in the process of redesigning and relocating the CIRCM control panel for easier pilot access.
- Cybersecurity testing demonstrated the system has minor vulnerabilities that the Army can mitigate.

Recommendation

1. The Army should mitigate the minor cybersecurity vulnerabilities identified during testing.

Counter-Small Unmanned Aerial Systems (UAS) Systems



Executive Summary

- In July 2019, USD(A&S) requested DOT&E's support in assessing the operational performance of a select set of counter-small unmanned aircraft systems (C-sUAS) systems as installed, integrated, and employed in an operationally representative environment.
- In collaboration with the Combatant Commands, Service representatives, and the Joint Deployable Analysis Team (JDAT) (part of Joint Chiefs of Staff/J6), DOT&E developed an assessment plan for 11 C-sUAS systems (Table 1) at 5 locations outside the continental United States (OCONUS). JDAT executed the OCONUS assessment plan between November 2019 and March 2020 under DOT&E oversight.
- DOT&E also participated in test planning, observation, and administration of two Service-led C-sUAS system tests within the continental United States (CONUS) in February and March 2020.
- In April 2020, DOT&E delivered an independent analysis of the OCONUS data to the newly formed, Army-led Joint C-sUAS Office (JCO) in support of their C-sUAS down-selection task.
- In May 2020, the SECDEF accepted the JCO recommendations to down-select from 28 fielded C-sUAS systems to 7.

System

- C-sUAS systems are designed to detect, track, identify, and defeat or disable small (Groups 1 and 2) unmanned aircraft systems (sUAS). Common methods for detecting sUAS include radars, radio frequency (RF) scanners, and electro-optical (EO) or infrared (IR) cameras. Common defeat methods include jamming the sUAS RF control or video link, jamming sUAS Global Navigation Satellite System signals, or destroying the sUAS using a kinetic mechanism, such as lasers, projectiles, or an intercepting sUAS.
- Based on inputs from USD(A&S) and U.S. Central Command, DOT&E assessed a select set of widely employed C-sUAS systems (listed in Table 1) against Group 1 sUAS. Most systems relied on RF jamming to defeat or disable sUAS. The two exceptions were the Land-Based Phalanx Weapon System (LPWS) and Howler, which employ kinetic defeat mechanisms.
- Fixed-site systems typically use multiple methods to detect, track, and identify sUAS, including radars, RF sensors to detect the wireless signals used to control sUAS or provide video feeds, and EO/IR or visual cameras to detect the sUAS' visual or heat signature. These systems often combine these methods to provide a multi-layer capability, which requires an effective human interface and command and control capability that integrates and networks the various sensors to provide actionable information to the system operator.
- Mobile systems generally consist of fewer components and might use only one method to detect, track, and identify sUAS.

Mission

A unit equipped with a C-sUAS capability detects, tracks, and identifies the presence of sUAS and provides kinetic and non-kinetic means to destroy or negate the ability of the adversary sUAS to complete its mission (either intelligence, surveillance, and reconnaissance; or attack).

- Fixed-site systems provide broader defense of a base or installation and typically constitute a portion of the overall layered defense strategy.
- Mobile systems are designed to be more agile, scalable, and maneuverable. They can be moved within a forward operating

base to protect high-value assets or installed on mobile platforms to protect units on the move.
- Handheld or soldier-worn systems are often employed as a component of a fixed-site system to engage sUAS at short range. Some handheld systems cannot detect sUAS and must therefore be cued to the sUAS location or rely on visual detection by the operator.

Major Contractors
- Varies by C-sUAS system. See Table 1.

TABLE 1. C-SUAS SYSTEMS ASSESSED BY DOT&E					
C-sUAS Category	**System Name**	**Detection Methods**	**Defeat Methods**	**Service**	**Major Contractor / Lead Integrator**
Fixed or Semi-Fixed Systems	Counter-Remote Control Model Aircraft Integrated Air Defense Network (CORIAN) versions 1.5 and 1.8	RF	RF, GPS	Army	CACI
	Fixed Site-Low, Slow, Small Unmanned Aerial Vehicle Integrated Defeat System (FS-LIDS)	RF, radar, camera	RF, GPS	Army	SRC, Inc.
	Medusa System of Systems	RF, radar, EO/IR	RF, GPS	Air Force	SAIC
	Expeditionary-Marine Air Defense Integrated System (E-MADIS)	RF, radar, camera	RF, GPS	Marine Corps	Naval Surface Warfare Center, Crane Division
	Land-Based Phalanx Weapon System (LPWS)	Radar, EO/IR	20-mm M940 ballistic round	Army	Raytheon
Mounted or Mobile Systems	Light-Marine Air Defense Integrated System (L-MADIS)	RF, radar, cameras	RF, GPS	Marine Corps	Naval Surface Warfare Center, Crane Division
	Howler	Radar, EO/IR	Coyote UAS	Army	Raytheon
	EnforceAir	RF	RF	N/A – Israeli System	D-Fend Solutions
Handheld or Soldier-Worn Systems	Drone Restricted Access Using Known EW (DRAKE) (backpack version)	RF	RF	Navy	Northrop Grumman
	Drone Defender	RF, visual	RF, GPS	Army	DeDrone
	Dronebuster	Visual	RF, GPS	Army	Flex Force
EW – Electronic Warfare; EO – Electro-optical; IR – Infrared; RF – Radio Frequency; UAS – Unmanned Aerial System; C-sUAS – Counter-Small Unmanned Aircraft Systems					

Activity
- From November 8, 2019, through March 13, 2020, JDAT executed OCONUS testing in accordance with the DOT&E-approved test plan. The JDAT team executed 281 record test sorties using 11 C-sUAS systems (listed in Table 1) across 5 U.S. Central Command locations. A DOT&E representative was part of the test team for three of the sites, and DOT&E representatives were part of the CONUS support team at JDAT. In coordination with JDAT, DOT&E approved regular test modifications required by operational realities.
- From February 28 through March 4, 2020, the Marine Corps executed the follow-on CONUS testing of the Light-Marine Air Defense Integrated System (L-MADIS) C-sUAS system at Yuma Proving Ground, Arizona. Testing consisted of 60 record test sorties.
- From March 9 – 12, 2020, the Air Force executed follow-on CONUS testing of the Medusa C-sUAS system at Edwards AFB, California. Testing consisted of 61 record test sorties.
- DOT&E representatives assisted in planning and data collection during CONUS tests. Tests were conducted in accordance with DOT&E recommendations.
- JDAT and the Services conducted the OCONUS and CONUS tests using adversarial Red Teams flying a range of realistic fixed- and rotary-wing sUAS flight profiles. Testing considered both single and multiple sUAS threats with a focus on commercial off-the-shelf Group 1 sUAS weighing less than 20 pounds.
- In April 2020, DOT&E completed and delivered an independent analysis of OCONUS and CONUS test data to the JCO in time to support their C-sUAS down-select analyses and comeback brief to the SECDEF.
- In May 2020, the SECDEF accepted the JCO recommendations to down-select from 28 fielded C-sUAS systems to 7. Services will sustain previously fielded systems until replacement systems are available, but will not conduct additional research, development, test, and evaluation on the non-selected systems.

Assessment
- OCONUS and CONUS testing were adequate to assess C-sUAS system capability to detect, identify, track, and

prevent an adversarial force from accomplishing sUAS reconnaissance or attack missions.

- Group 2 UAS were not available in the time frame needed to support testing. Group 3 UAS were considered to be outside the scope of OCONUS and CONUS test efforts at the time of testing. Additionally, swarm UAS threats were not utilized as a potential threat.
- Software tools currently installed on threat sUAS systems for security reasons introduced test limitations that might have affected the observed C-sUAS performance.
- OCONUS testing occurred on systems as installed, integrated, and operated at each location. The rules of engagement (ROE) and tactics, techniques, and procedures (TTPs) for employing C-sUAS systems varied by system and location. ROEs and TTPs at certain locations might have adversely affected C-sUAS system performance. For example, lengthy ROE hinder timely engagements.
- CONUS testing occurred at the test ranges using the advanced versions of the Medusa and L-MADIS C-sUAS systems as compared to those assessed OCONUS. CONUS testing permitted a greater degree of control to assess the effect of test conditions that could not be systematically varied during OCONUS testing and offered a less cluttered RF environment to the C-sUAS system operators. Approvals to use some C-sUAS defeat capabilities within the United States can take up to 6 months to obtain so, in the interest of time, CONUS testing could not include the full spectrum of C-sUAS defeat mechanisms.
- C-sUAS detection capabilities were adequate for most systems. Engagement (defeat) continues to be a challenge. A system-of-systems approach to C-sUAS yielded the highest performance.
- Reliability and maintainability shortfalls degraded the capability of some C-sUAS systems. In addition, for several systems, operators indicated that they had limited training and experience on the system.
- The details of the C-sUAS system performance across the kill chain are classified and available on request.

Recommendations

The Army-led JCO should:

1. Monitor Services' plans to execute operationally representative assessments of C-sUAS system performance prior to fielding. An operationally representative assessment should include trained operators (including military members when deployed with military operators), Red Teams trained to fly realistic and unpredictable threat flight profiles, and a range of electromagnetic spectrum environments (spanning rural to dense urban environments) and environmental conditions (including coastal, urban, maritime, and forested).
2. Develop a set of standardized measures of performance, measures of effectiveness, operational assessment protocols, ROEs, and TTPs for use in C-sUAS system operational assessments to enable meaningful performance comparisons across C-sUAS and to enable measures of progress in C-sUAS performance over time.
3. Include Group 2 and 3 UAS and swarm UAS threats in future operational assessments. Future range upgrades should consider installing optical and RF tracking systems to execute simultaneous tracking of multiple targets and instrumentation. This is needed in order to quantify the significance of the effect on individual elements, as well as potential interactions between elements within a swarm. Test ranges will also need to maintain (and potentially expand in the future) sufficient operational space to support the increasing performance and ranges of UAS, particularly for the larger Group 3 UAS.
4. Ensure that operators are sufficiently trained before conducting testing and deployment, and that their training and Military Occupational Specialty (where applicable) properly represents operational users.
5. Explore options to reduce timelines for waivers and authorization needed to employ a full spectrum of C-sUAS defeat mechanisms in operational assessments to maintain pace with the evolving sUAS threat.
6. Investigate alternative software tools for protecting sUAS information during testing that do not adversely affect the ability to accurately evaluate C-sUAS performance.

Extended Range (ER) Guided Multiple Launch Rocket System (GMLRS)

Executive Summary

- The Guided Multiple Launch Rocket System (GMLRS) is comprised of three fielded variants: Dual-Purpose Improved Conventional Munitions (DPICM), Unitary, and Alternative Warhead (AW).
- On May 19, 2017, the Army Acquisition Executive (AAE) signed a Modification Authorization Memorandum to execute Extended Range (ER) GMLRS as an Engineering Change Proposal (ECP) to the current production of GMLRS Unitary and AW. ER GMLRS offers an extended range in all weather conditions.
- In October 2019, the Army executed legacy GMLRS test shots against jamming countermeasures to increase their modeling and simulation (M&S) capabilities.
- On August 3, 2020, DOT&E approved the ER GMLRS Test and Evaluation Master Plan (TEMP) Annex.
- The Army plans to execute the first ER GMLRS Engineering Developmental Test shots in early November 2020, followed by integrated test/system qualification test shots against representative targets beginning in May 2021 and IOT&E beginning in November 2021. DOT&E will write a combined operational and live fire test report.

System

- The GMLRS is comprised of three fielded variants: DPICM, Unitary, and AW.
- The proposed ER GMLRS ECP expands the rocket motor diameter to increase range, modifies the control section for enhanced maneuverability, and incorporates a side-mounted proximity sensor to enable higher height-of-burst.
- The ER GMLRS uses a GPS-aided inertial navigation system, aft-mounted control actuation system, and either a Unitary or AW warhead variant to engage point and area targets.
- Army units will fire the ER GMLRS rockets from the wheeled M142 High Mobility Artillery Rocket System and M270A2 launcher.

Mission

Commanders will use the ER GMLRS rockets to engage long-range point or area-located targets including air defense, command posts, and high value targets without the hazard of unexploded sub munitions.

Major Contractor

Lockheed Martin Missiles and Fire Control – Grand Prairie, Texas; assembled in Camden, Arkansas

Activity

- On May 19, 2017, the AAE signed a Modification Authorization Memorandum to execute ER GMLRS as an ECP to the current production of GMLRS Unitary and AW variants. ER GMLRS offers an extended range in all weather.
- In October 2019, the Army executed legacy GMLRS test shots against jamming countermeasures to increase their M&S capabilities.

- On August 3, 2020, DOT&E approved the ER GMLRS TEMP Annex.
- The scheduled test plan shifted 6 months due to the impacts of the coronavirus (COVID-19) pandemic and long lead hardware availability.
- The Army plans to execute the first ER GMLRS Engineering Developmental Test shots in early November 2020, followed by integrated test/system qualification test shots against representative targets beginning in May 2021 and IOT&E beginning in January 2022. Integrated testing will use operationally realistic targets.
- The ER GMLRS test program will provide sufficient data for DOT&E to evaluate the operational effectiveness and mission processing tactics, techniques, and procedures. DOT&E will use a combination of lethality damage assessments, M&S results, and observations of a targeting cell to evaluate the lethality and operational effectiveness of the ER GMLRS.
- The IOT&E consists of a command post exercise phase and a flight phase to provide an operationally realistic context for evaluating the timely and accurate employment of ER GMLRS.
- The ER GMLRS program plans to leverage cybersecurity testing of the ER GMLRS munition, launcher fire control system, launcher and munition test device, and Advanced Field Artillery Tactical Data System (AFATDS). The program is planning to leverage a system-of-system architecture for cybersecurity.
- The Army's test program includes a combined cooperative vulnerability and penetration assessment and an adversarial assessment event in conjunction with AFATDS programs in 4QFY21. The convergence of supporting fire control system and AFATDS software releases will drive the timing of these events. DOT&E is working with the Army to plan AFATDS software testing if not conducted during IOT&E.
- The test plan includes a High Mobility Artillery Rocket System with the updated fire control system. The current test plan does not include the M270A2 launcher with the updated fire control system. DOT&E is working with the Army to plan M270A2 launcher testing if not conducted during IOT&E.
- The current test program does not include firing the ER GMLRS Unitary delay mode. The flight termination system is required when firing in the continental United States. The flight termination system will not fit in the Unitary delay mode. DOT&E is working with the Army to find a test venue outside of the continental United States to test this variant.

Assessment

- The legacy GMLRS shots against GPS jamming produced data that can be used to verify the Army's M&S efforts.
- The scheduled test plan shifted 6 months due to the impacts of COVID-19 and long lead hardware availability; based on the scheduled integrated testing, DOT&E will have an assessment in FY22.

Recommendations

The Army should:

1. Develop a plan to test the ER GMLRS unitary delay mode in an operational realistic environment.
2. Synchronize AFATDS software releases and the development of the M270A2, and new fire control system to incorporate these platforms in the integrated operational testing.
3. Consider additional GPS jamming in integrated testing.
4. Conduct follow-on testing in the event AFATDS software testing and M270A2 launcher with the updated fire control system are not completed during IOT&E.

Infantry Squad Vehicle (ISV)

Executive Summary

- The Program Executive Office, Combat Support and Combat Service Support (PEO, CS&CSS), approved the Infantry Squad Vehicle (ISV) program to enter Milestone C (MS C) low-rate initial production (LRIP) in June 2020.
- The Army awarded the ISV LRIP contract to General Motors Defense.
- DOT&E provided the ISV Operational Assessment (OA) to support the PEO ISV MS C decision.
- The ISV Program Office completed development of the ISV MS C Test and Evaluation Plan (TEMP) to reflect the T&E for the production and deployment phase. The Army did not submit the ISV TEMP for OSD approval prior to MS C. The Army plans to have the TEMP approved by the start of developmental testing.
- The Army Test and Evaluation Command (ATEC) plans to conduct the ISV IOT&E in August 2021 at Fort Bragg, North Carolina.

System

- The ISV is the program of record that evolved from the Army Ground Mobility Vehicle. The ISV provides mobility on the battlefield for a nine-soldier light Infantry Squad with their associated equipment. The vehicle has a payload requirement of 3,200 pounds to support the Infantry Squad conducting 72-hour operations.
- The ISV has a maximum vehicle curb weight of 5,000 pounds to meet the requirement for external transport by the UH-60. The vehicle is required to be external and internal transportable by a CH-47F helicopter and airdropped by C-17 and C-130 aircraft.

Mission

Infantry Brigade Combat Team commanders employ the ISV to provide mobility and logistics support capability to conduct engagement, security, deterrence, and decisive action missions. Airborne and air assault Brigade Combat Teams employ the ISV during austere and offset entry operations to provide rapid cross-country mobility to conduct initial entry and offensive operations.

Major Contractor

General Motors Defense – Detroit, Michigan

Activity

- ATEC conducted schedule-driven developmental testing (DT) of three vendors' prototype ISV from December 2019 through January 2020.
- In January 2020, the ISV Program Office conducted the ISV Soldier Touchpoint 2 (STP2) at Fort Bragg, North Carolina. The program manager assessed the performance of three vendors' ISV when operated by Army rifle squads accomplishing selected infantry tasks during STP2. General Motors Defense, Oshkosh Corporation/Flyer Defense, and Science Application International Corporation (SAIC)/Polaris provided ISV test articles. The STP2 was not an operational test. DOT&E did not approve the STP2 test plan.
- The ISV Program Office completed development of the ISV MS C TEMP to reflect the T&E for the production and deployment phase. The Army did not submit the ISV TEMP for OSD approval prior to the MS C decision. The Army plans to submit the TEMP before the start of developmental testing.
- In June 2020, DOT&E provided the ISV MS C OA to support the PEO for the ISV MS C decision.

- The PEO CS&CSS approved the ISV program to enter MS C LRIP in June 2020.
- The Army awarded the ISV LRIP contract to General Motors Defense.
- ATEC plans to conduct the ISV IOT&E in August 2021 at Fort Bragg, North Carolina.

Assessment

- Based on performance demonstrated in STP2 and DT, the ISV provides enhanced off-road mobility capability and enables infantry units to be less predictable in their movement necessary to accomplish airborne; air assault; offensive; and engagement, security cooperation, and deterrence (ESD) missions. The ISV expands a light infantry unit's area of operations. Squads equipped with ISVs accomplished nine movement tasks consisting of 50 miles each during the STP2. All ISVs were capable of carrying a nine-soldier infantry squad with their personal weapons and equipment during movement.
- The ISV has not demonstrated the capability to carry the required mission equipment, supplies, and water for a unit to sustain itself to cover a range of 300 miles within a 72-hour period. The lack of internal space to carry soldiers with their rucksacks in seats, mission-essential equipment, and sustainment loads may create a logistics and operational burden. This limits the type and duration of missions for which an ISV may be effective. Units operating for long duration will need to conduct mission planning, cross-level equipment across the unit, or may require additional ISVs to sustain operations.
- The Army did not conduct airborne, air assault, offense, defense, and ESD missions during the STP2. All ISVs have the capability for internal transport by C-17 and CH-47F in support of airborne missions. Based on DT, all ISVs meet the weight and dimension requirements to fit inside a C-17 and CH-47F, and meet the 5,000-pound weight limit to permit sling loading with CH-47F and UH-60 helicopters. The Army plans to test and evaluate the ability of an ISV-equipped unit to accomplish these missions during IOT&E.
- Units equipped with ISVs lack reliable communication capability using hand-held radios and manpack radios over the distances of 62 to 300 miles required to accomplish missions. The ISV does not have a requirement for a mounted communication capability. During the STP2, each squad depended on their squad radios while employing ISVs. Communication between the squad leader, soldiers, and the platoon leader was intermittent and not reliable.
- General Motors Defense ISV demonstrated the highest reliability amongst the three vendors in DT. The General Motors Defense ISV demonstrated a 585 mean miles between operational mission failure (MMBOMF) versus the user requirement of 1,200 MMBOMF.
- All vendors' ISVs are cramped and soldiers cannot reach, stow, and secure equipment as needed, degrading and slowing mission operations. During the STP2, soldiers on all ISVs could not readily access items in their rucksacks without stopping the movement, dismounting, and removing their rucksacks from the vehicle.
- The ISV does not have an underbody and ballistic survivability requirement. The ISV-equipped unit will be susceptible to enemy threats and actions. All ISVs have some design features to reduce a unit's vulnerability to enemy detection such as speed, and a small, low profile design that minimize their visual detectability. In order for the ISV-equipped unit to avoid threats and traverse terrain that is covered and concealed, the ISV will give up some of its inherent speed advantage.

Recommendation

1. The Army should develop a plan to address recommendations identified in the DOT&E MS C OA before initial production of the ISV.

Initial Maneuver Short-Range Air Defense

Executive Summary

- The Army is acquiring Initial Maneuver Short-Range Air Defense (IM-SHORAD) in response to a 2018 Directed Requirement to provide a short-range air defense capability in support of Operation Atlantic Resolve.
- On September 2, 2020, the Chief of Staff of the Army made the acquisition decision for 32 IM-SHORAD vehicles prior to operational testing.
- The Army plans to conduct an operational assessment (OA) at White Sands Missile Range (WSMR), New Mexico, from October 26 to December 18, 2020.
- An Expeditionary Operational Assessment after fielding is planned for FY22 in Germany.
- The Army conducted a cooperative vulnerability and penetration assessment (CVPA) from August 31 to September 4, 2020, and an adversarial assessment (AA) from October 26 to November 6, 2020.
- The Army started the live fire testing and evaluation of IM-SHORAD in February 2020. The survivability and lethality testing is expected to complete in 1QFY21.
- DOT&E will publish a report summarizing the OA, live fire, and cybersecurity assessment findings in 3QFY21.

System

- The IM-SHORAD system of systems integrates Stinger and Longbow HELLFIRE missile interceptors onto a Reconfigurable Integrated Weapons Platform (RiWP) with a 30-mm cannon, 7.62x39 coaxial machine gun, and electro-optical sight system. The system includes a Multi-Hemispheric Radar (MHR) to provide onboard sensing capabilities. The RiWP and MHR combined are the Mission Equipment Package, which is mounted to a Stryker Double-V Hull A1. IM-SHORAD uses Forward Area Air Defense Command and Control.
- Each IM-SHORAD Stryker vehicle is an independent fire unit. IM-SHORAD platoons consist of four vehicles. IM-SHORAD battalions include 36 vehicles, broken into 3 batteries, each with 3 platoons. Each IM-SHORAD battery has a single AN/MPQ-64 Sentinel radar as its primary sensor.
- The 2018 Directed Requirement authorizes the Army to purchase additional IM-SHORAD vehicles.

Mission

The Joint Force Commander and Ground Maneuver Commander employ IM-SHORAD to protect other maneuvering combat units in Armored Brigade Combat Teams and Stryker Brigade Combat Teams from fixed-wing, rotary-wing, and Group 3 (medium-sized) unmanned aerial systems. One IM-SHORAD battery provides protection for a brigade-sized maneuver element.

Major Contractors

- Vehicle: General Dynamics Land Systems – Detroit, Michigan
- Mission Equipment Package: DRS Sustainment Systems – St. Louis, Missouri
- Stinger Vehicle Universal Launcher: Raytheon Missiles & Defense – Tucson, Arizona

Activity

- The original Army desire was to conduct an IOT&E to determine the operational effectiveness, operational suitability, and survivability of the IM-SHORAD.
- In February 2020, the Army and DOT&E agreed upon an OA to support the evaluation of the directed requirements.
- The Army plans to conduct the IM-SHORAD OA from October 26 to December 18, 2020, at WSMR. This consists of a Search & Track (S/T) phase to assess the radar and command and control performance, a Missile Flight Test (MFT) to assess Longbow HELLFIRE performance and lethality, and a Sustainment phase in which soldiers operate the system while conducting 72-hour simulated combat operations.
- The Army conducted Weapon Safety and Performance Testing from April 14 to August 6, 2020, at WSMR; Redstone Arsenal, Alabama; and Aberdeen Proving Ground, Maryland, in support of a safety release for the OA. Following this testing, the Army conducted a series of Special Test Cases to demonstrate fulfillment of the directed requirements.

The Army halted these tests due to problems with the Stinger Vehicle Universal Launcher and MEP software on May 13, 2020, and restarted the testing on July 21, 2020, with updated MEP software. The Army continued to improve the software to resolve integration prior to the OA.
- Prior to operational testing, the Chief of Staff of the Army made a decision to purchase 32 of the IM-SHORAD vehicles.
- The Army conducted a CVPA from August 31 to September 4, 2020, and plans to conduct an AA from October 26 to November 6, 2020, as part of the operational assessment.
- The Army developed an LFT&E Strategy, which DOT&E approved in February 2020 as adequate to evaluate the survivability of IM-SHORAD against operationally representative kinetic threats.
- The Army started survivability testing of IM-SHORAD in February 2020 and expects to complete it in 1QFY21.
- The Army is developing a Live Fire Lethality Test Design Plan to support the evaluation of IM-SHORAD lethality against operationally representative targets.
- Due to the coronavirus (COVID-19) pandemic, Mode 5 Identification of Friend or Foe (IFF) compatibility testing, which was planned for late April 2020, was not completed. IFF testing is expected to be complete in 1QFY21. A compatibility certificate is required for fielding and will ensure IM-SHORAD can accurately identify allied or threat aircraft, reducing the chance of fratricide or misidentification. IFF testing was not part of developmental or operational testing.

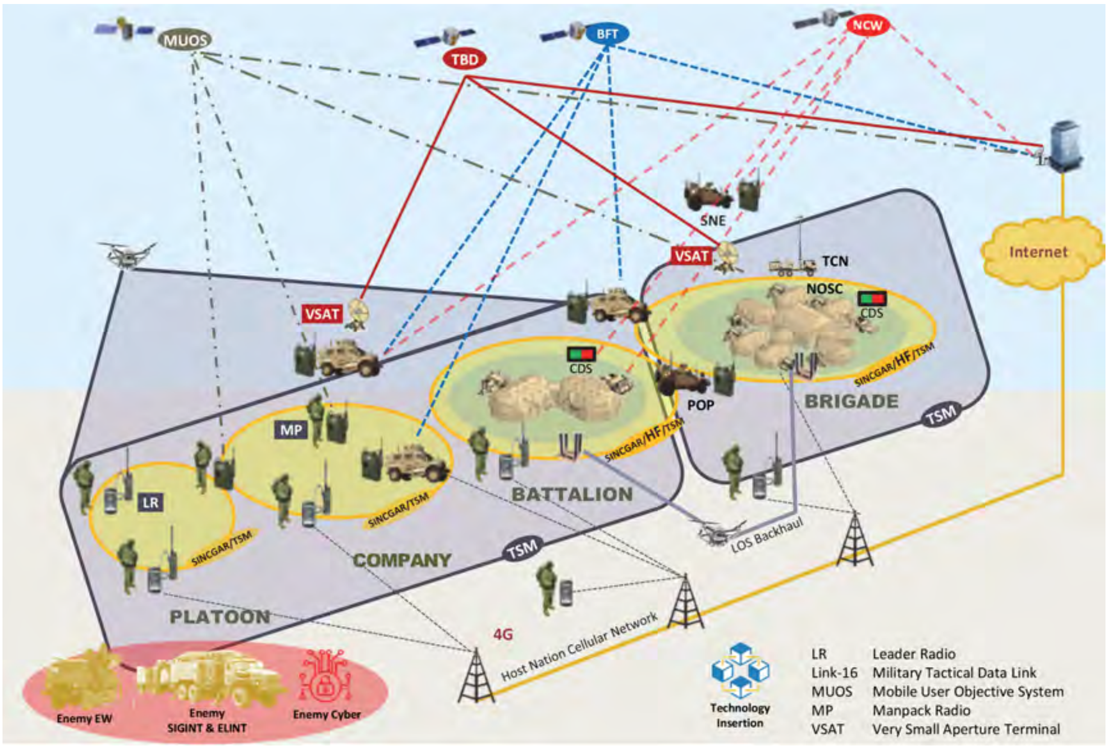
Assessment

- The Army intends to assess the IM-SHORAD against a directed requirement; the Army G2 did not accredit the targets used during the OA as threat representative, hindering the ability to evaluate the effectiveness and lethality of IM-SHORAD against operationally representative targets for the HELLFIRE Longbow missile.
- The OA was not executed in an operationally representative electromagnetic spectrum contested environment with threat-representative electronic warfare systems attacking the system. Operationally relevant electronic attacks test the IM-SHORAD's ability to be effective on the battlefield. DOT&E will work with the Army to include realistic electronic warfare/electronic attack in future operational testing.
- DOT&E will publish results of the CVPA and AA as part of the OA report in 3QFY21.
- The IM-SHORAD fire units used during the OA were prototypes that will require retrofitting prior to fielding. The Army has not yet funded future operational testing with production-representative vehicles.
- The HELLFIRE Longbow missile lethality assessment versus fixed- and rotary-wing targets is reliant on accurate air target signature models, which are currently of low fidelity and need to be adequately verified, validated, and accredited.
- Although there is no reliability requirement for IM-SHORAD, the Army intends to collect reliability data during the OA. The Army will include reliability incidents in its report.
- DOT&E will publish a report summarizing the OA, live fire, and cybersecurity assessment findings in 3QFY21.

Recommendations

The Army should:
1. Conduct an IOT&E assessing system performance with production-representative vehicles against accredited threats supporting both Armor Brigade Combat Team and Stryker Brigade Combat Teams in a realistic hostile electronic environment.
2. Improve credibility of the HELLFIRE Longbow missile lethality assessments against fixed- and rotary-wing targets through adequate accreditation of air target signature models.
3. Consider assessing system reliability during developmental and operational testing.

Integrated Tactical Network (ITN)



BFT – Blue Force Tracker, CDS – Cross Domain Solution, ELINT – Electronic Intelligence, EW – Electronic Warfare, HF – High Frequency, LR – Leader Radio, MP – Manpack, MUOS – Mobile User Objective System, NCW – Net Centric Waveform, NOSC – Network Operations Security Center, LOS – Line of Sight, POP- Point of Presence, SINCGARS – Single Channel Ground and Airborne Radio System, SIGINT – Signals Intelligence, SNE – Soldier Network Extension, TBD – To Be Determined, TCN – Tactical Communications Node, TSM – Tactical Scalable Mobile Ad-hoc Network, VSAT – Very Small Aperture Terminal

Executive Summary

- The Army continues to develop and evaluate the Capability Set 21 (CS21) Integrated Tactical Network (ITN) in preparation for a rapid fielding decision for four Infantry Brigade Combat Teams (IBCTs) planned for December 2020.
- Real-world events for 1st Brigade/82nd (1/82) Airborne Division, including deployment to Kuwait, the coronavirus (COVID-19) pandemic, and deployment to the Washington, D.C. area, have delayed the completion of full brigade evaluations of the ITN in FY20.
- The December 2020 fielding decision will include evaluation of the ITN from the September 2020 Soldier Touch Point (STP). Complete results from the November 2020 technical test and the March 2021 combat training center rotation will not be included in the December 2020 fielding decision. They will inform a full fielding decision for five additional brigades in May 2021.
- The Army intends the combination of test events to serve as the Section 804 operational demonstration supporting rapid fielding and will determine operational effectiveness, suitability, and survivability for the May 2021 fielding decision.

System

- The ITN, a component of CS21, is a suite of communications and networking hardware and software that provides voice and data communication capabilities to tactical units. The Army intends the ITN to provide an expeditionary, tactical network that is converged, resilient, and reliable in a congested and contested environment. The Army intends ITN to enable leaders to fight their formations where they choose and conduct mission command in all operational environments.
- The ITN will meet these requirements incrementally through a capability set acquisition and fielding model starting with CS21. CS21 integrates existing fielded systems, programs transitioning to production, and commercial off-the-shelf equipment through a middle tier of acquisition (MTA) rapid prototyping effort. The Army intends ITN to change and evolve as new capabilities become available for future capability sets.
- Components of CS21 include:
  - Existing Fielded Systems – Warfighter Information Network – Tactical, Joint Battle Command – Platform, Nett Warrior, Advanced Field Artillery Tactical Data

System, and On-the-Move and At-the-Halt Satellite Communications (SATCOM).
  - Systems Entering Production – Handheld, Manpack, and Small Form Fit (HMS) Manpack, HMS Leader Radio, Command Post Computing Environment, Command Post Integrated Infrastructure, Terrestrial Transmission Line of Sight, Unified Network Operations, Precision Fires – Dismounted, Tactical Defensive Cyber Infrastructure, and Cyber Situational Understanding.
- The CS21 ITN equipment break out by Platoon/Squad and Company/Battalion/Brigade unit level includes:
  - Platoon/Squad – Trellisware TW-950, Trellisware TW-875, Android Tactical Assault Kit (ATAK) Tablet, secure but unclassified (SBU) end-user device (EUD), and Windows Tactical Assault Kit (WinTAK) software.
  - Company/Battalion/Brigade – Tactical Cross Domain Solution (TACDS), Tactical Radio Application Extension (TRAX) software, Tactical Radio Integration Kit (TRIK), Tactical Assault Kit (TAK) server software, Variable Height Antenna (VHA), Mobile Broadband Kit (MBK), Silvus Streamcaster 4400 & 4200, Transportable Tactical Command Communications (T2C2) – Heavy, T2C2 – Light, and Scout satellite terminal.

Mission

The ITN-equipped Brigade Combat Team (BCT) conducts Multi-Domain Operations in the Joint Operating Environment with essential mission command capabilities. The ITN operates throughout a full range of military operations. The ITN enables leaders to fight their formations where they choose, and converges disparate transmission systems into a single network. The ITN-equipped BCT conducts mission command in all operational environments with a resilient and reliable network in congested and contested environments at the point of need. The C2S1 ITN is focused on capabilities provided to the IBCT formation.

Major Contractors

- 4K Solutions: MBK – Midland, Georgia
- GATR: T2C2 – Huntsville, Alabama
- General Dynamics Mission Systems: TACDS – Fairfax, Virginia
- Hoverfly Technologies Company: VHA – Orlando, Florida
- KLAS Telecom: TRIK – Herndon, Virginia
- Pacstar: Baseband Terminals – Portland, Oregon
- PAR Government: WINTAK and ATAK software – Raleigh, North Carolina (U.S. Government owned software)
- Samsung: EUD (Galaxy S7) – San Jose, California
- Sierra Nevada Corporation Integrated Mission Systems: TRAX – Hagerstown, Maryland
- Silvus: Streamcaster 4400, Streamcaster 4200 – Los Angeles, California
- Tampa Microwave: Scout Terminals – Tampa, Florida
- Trellisware: TW-950, TW-875 – San Diego, California
- Verizon: Cellular plan for MBK – New York, New York

Activity

- The Army conducted a technical test of the ITN in December 2019. The focus was to assess the ability of the SBU network to pass voice and data in a variety of environmental conditions. The program manager intended the 2-week test to serve as a risk reduction for the January 2020 STP. Problems collecting and reducing the data produced from the mission command systems made most of the network data from the tactical radios not usable.
- The Army conducted scalability tests in February and July 2020 in order to determine how many radios could join and operate on a single network. The Army collected technical data, which they used to design battalion-sized, flat networks of up to 350 nodes for units equipped with the ITN.
- In May 2020, the Army conducted a review of the ITN equipment and made critical decisions as to what the first fielded iteration of the ITN would look like.
  - The Army is fielding this equipment to the 1/82 to serve as the experimentation Brigade for fielding decisions in December 2020 and May 2021.
  - The DevOps strategy planned for FY21 includes a technical test that will assess the current configuration of equipment and stress that configuration under electronic warfare conditions.
  - Any changes, to include any new equipment, will be assessed in a Brigade-level combat training center rotation in March 2021. The Joint Readiness Training Center (JRTC) training rotation will serve as the first time that a Brigade-level ITN will be fielded and the ability to conduct ITN-enabled mission command assessed.
- Real-world events for 1/82 Airborne Division, including unexpected deployment to Kuwait, the COVID-19 pandemic, and deployment to the Washington, D.C. area, have delayed the completion of the full brigade evaluation in FY20.
- The Army Test and Evaluation Command conducted the STP in September 17 – 24, 2020, during a training exercise with the 1/82. The STP included one battalion and a slice of the brigade headquarters conducting training exercises in the field.

Assessment

- There has not been an opportunity to evaluate the operational effectiveness, suitability, or survivability of an ITN-equipped IBCT under its current configuration, because of the delays in testing due to real-world events. The Army does not intend to conduct a formal operational test, but intends the combination of test events to serve as the Section 804 operational

demonstration supporting rapid fielding. The Army plans to submit the ITN Test and Evaluation strategy to DOT&E for approval.
- The ITN is currently being developed under the Army's DevOps strategy. After each event, changes are made to software, configurations, and some equipment in order to improve the performance of the network. This strategy is effective for designing a system-of-systems network.
- The December 2020 fielding decision of four IBCTs will include evaluation of the ITN from the September 2020 STP. Complete results from the November 2020 technical test and from the planned March 2021 combat training center rotation will not be included in the December 2020 fielding decision. This early fielding decision, based on limited data, constitutes a risk of fielding equipment to brigades that is not effective.
- Soldier feedback from the September STP indicated that the ITN network configuration and instantiation is not intuitive as currently designed and requires a robust training program.

Recommendations

The Army should:
1. Continue the DevOps cycle to evaluate and improve the ITN. This process should continue to have regular governmental testing that includes both soldier feedback and test instrumentation.
2. Delay fielding decisions for the ITN until the Brigade-level JRTC rotation in 2021. This delay will allow the Army to decide on the first operational fielding of the ITN based on the experiences of a full Brigade using the equipment as well as complete analysis from the technical test. This may allow for determination of operational effectiveness, suitability, and survivability.
3. Develop a robust operator and maintainer training program to support ITN fielding.
4. Submit the Test and Evaluation strategy to DOT&E for approval.

Integrated Visual Augmentation System (IVAS)

Capability Set 2

Capability Set 3

Executive Summary

- In 1QFY20, the Army executed Soldier Touchpoint (STP) 2 to assess Integrated Visual Augmentation System (IVAS) Capability Set (CS) 2 prototypes in an operational environment.
  - CS 2 prototypes demonstrated increased capability from CS 1, including the ability to integrate GPS, tactical radios, and rapid target acquisition (RTA); fuse low-light and thermal imagery; and simultaneously operate up to 50 systems within squad and platoon exercises.
  - Conventional soldiers and marines responded favorably to the perceived usefulness of CS 2. Special Forces and Army Rangers responded favorably to person of interest identification, text translation, and squad reconnaissance capabilities. They did not consider most CS 2 capabilities to be an improvement over their current thermal, low-light, and GPS equipment and capabilities.
  - Performance problems with GPS, imagery sensors, and RTA integration were noted during STP 2.
- DOT&E observed STP 2 and submitted an evaluation to Congress as requested by the Chairman, Senate Armed Services Committee.
- Due to the coronavirus (COVID-19) pandemic, the Army delayed STP 3 from July to October 2020. The Army will assess CS 3 in STP 3 to support the decision to move from rapid prototyping into rapid fielding. As with the previous capability sets, DOT&E observed STP 3 and will evaluate CS 3.

System

- IVAS includes a heads-up display (HUD), body-worn computer (puck), networked radio, and three conformal batteries for each soldier. The system includes an advanced battery charger for each platoon and a tactical cloud computing capability, known as Bloodhound, for each company.
- The Army intends for IVAS to increase close combat lethality by providing improved communication, mobility, situational awareness, and marksmanship.
- The Army has structured IVAS as a middle tier of acquisition program with a 2-year prototyping period of four capability sets with software sprints and hardware builds. The Army and Microsoft define each capability set in a design review based on the results from the previous capability set and overarching program goals.
  - The IVAS CS 1 is Microsoft commercial HoloLens 2 with an integrated commercial, thermal sensor, and Tactical Assault Kit (TAK) software and maps. These prototypes operate on an internal battery and require a Wi-Fi network. The Army received 50 systems in March 2019.
  - The IVAS CS 2 included the integration of two low-light cameras, thermal sensor, tactical radio, TAK software and maps, rapid target acquisition, commercial GPS receiver, and conformal battery with Microsoft commercial HoloLens 2. The Army received 300 systems in October 2019.
  - The IVAS CS 3 will be the ruggedized military form factor with integrated low light and thermal sensors, TAK software and maps, and rapid target acquisition. The Army received 600 systems in September 2020.
  - The IVAS CS 4 will be the production-ready end-user device to provide enhanced squad lethality. The Army expects to receive 1,600 systems in April 2021 to support the initial operational test.
- IVAS provides a warfighting training tool through the Squad Immersive Virtual Trainer (SiVT). SiVT provides infantry fire teams the ability to enter and clear a shoot house of virtual combatants and non-combatants.

Mission

- Commanders of Army and Marine Corps close combat formations and Special Operations Forces units will employ IVAS to achieve overmatch against near-peer threats identified in the National Defense Strategy. The Army intends to evolve the concept of operations in coordination with the joint force through experimentation as the system capabilities mature.
- Squads will train with IVAS in the SiVT in a high fidelity, live and mixed reality, immersive environment enabling rapid conduct and repetition of training scenarios.

Major Contractor
Microsoft – software developed in Redmond, Washington, and hardware developed in Mountain View, California

Activity

- From October 28 through November 21, 2019, the Army executed STP 2 at Fort Pickett, Virginia, to assess CS 2 prototypes in an operational environment and demonstrate improvements from CS 1.
- Soldiers and marines executed squad-level exercises followed by platoon missions conducted against a nominal opposing force.
- DOT&E observed STP 2 and submitted an evaluation to Congress in May 2020 as requested by the Chairman, Senate Armed Services Committee. Since STP 2 was an experiment with prototype systems, the Army did not submit the STP plan to DOT&E for approval.
- STP 2 provided credible data collection opportunities. DOT&E assessed CS 2 using data from observations, focus groups, surveys, and success rates for specific operational subtasks within each task.
- Between STP 2 and STP 3, the Army has conducted multiple software sprint cycles and user juries to address problems found at STP 2.
- The Army delayed STP 3 from July to October 2020 due to the impacts of COVID-19. The Army executed STP 3 to assess CS 3, the first military form factor headset, at Fort Pickett, Virginia, with an Army company-sized unit. DOT&E observed STP 3 and will assess the operational capabilities of CS 3.

Assessment

- During STP 2, warfighters equipped with IVAS CS 2 demonstrated the following:
  - Dismounted navigation along a planned route during day and night. In daylight, warfighters reported increased speed of movement. The integrated GPS eliminated the need to self-locate and self-orient. At times, issues with commercial GPS accuracy led to inaccurate position location information. At night, poor low light and thermal sensor performance prevented some operational navigation activities.
  - Live target shooting on a static range during day and night using a rifle paired with the RTA capability, which makes the weapon's sight picture visible in a warfighter's headset. Warfighters were able to rapidly detect and engage targets from different shooting positions. At times, the headset limited the shooter's field of view and concussive forces from weapon firing caused the IVAS screen to blank out or freeze and return to normal without user intervention.
  - Mission planning and squad area reconnaissance during daylight conditions. Squad and team leaders developed and transferred mission plans, with the help of IVAS trainers, to each squad member in their headset prior to conducting mission rehearsals. Throughout reconnaissance activities, IVAS provided the squad with increased situational awareness and navigational capabilities. At the completion of a mission, squad leaders used the IVAS after-action review feature to playback the mission to the squad.
  - Stationary human target detection at night using the low-light and thermal sensors. At high moon illumination levels, soldiers could detect human targets in the open with low-light sensors. Warfighters' ability to detect human targets decreased with decreasing illumination from the moon. Warfighters used IVAS thermal capabilities to improve situational awareness. Thermal sensors experienced latency making movement challenging.
  - Platoon maneuvers during daylight and twilight conditions. A platoon-sized element of 49 warfighters conducted ambush and attack missions against a squad of threat forces. During these activities, IVAS proved most useful during maneuver to maintain formation and improve situational awareness, including detection of opposing forces that would have otherwise remained hidden. IVAS was least useful indoors, at night, and when in close contact with the enemy.
  - Clearing a building of reactive virtual SiVT targets and content using synthetic M4 weapons. Each squad repeated this activity multiple times under different configurations of civilians, hostages, and enemies who exhibited basic human actions and reactions. Following each run-through, warfighters received feedback in the after action reviews about their performance, including shots taken, kills, and shots received.
- Warfighters responded to surveys about overall user acceptance, contribution of IVAS to various test activities, and satisfaction.
  - User acceptance was unit-dependent and generally favorable for conventional Army forces from the 82nd Airborne and the Marines. Special Forces and Army Rangers responded favorably to person of interest identification, text translation, and squad reconnaissance capabilities. They did not consider most CS 2 capabilities to be an improvement over their current thermal, low-light, and GPS equipment and capabilities.
  - Problems with rapid target acquisition integration, low-light and thermal sensors, and GPS accuracy are reflected in low scores for IVAS support of shooting and land navigation activities.

- Warfighters commented on suitability issues with CS 2 IVAS prototypes to include: light discipline, lens fogging, discomfort during extended usage, and poor interoperability with current tactical combat gear were noted in warfighter comments.
- DOT&E, in concert with Army Test and Evaluation Command, Soldier Lethality Cross-Functional Team, and Program Manager IVAS, developed an early concept for testing IVAS in an initial operational test to support full-rate production.
  - DOT&E plans to use data from company-level force-on-force operations and squad-level live fire to evaluate whether a unit equipped with IVAS is more lethal than a unit that does not have IVAS.
  - DOT&E will rely on data collected from real-time casualty assessment instrumentation, IVAS-embedded instrumentation, surveys, and field observations to support the evaluation.
- The Army is working to determine how to integrate Multiple Integrated Laser Engagement System (MILES) onto IVAS-equipped soldiers.
- The Army Test and Evaluation Strategy is in draft. The Army intends to submit the Test and Evaluation Strategy to DOT&E for approval.

Recommendations

The Army should:

1. Complete a Test and Evaluation Strategy to outline what information is required to support full-rate production and rapid fielding decisions. Determine which developmental and operational test efforts are required to supply data for an evaluation.
2. Improve HUD light emissions, low-light cameras, thermal sensors, GPS accuracy, software reliability, rapid target acquisition integration, and TAK software integration.
3. Determine how IVAS and rapid target acquisition can integrate into existing training and testing instrumentation.
4. Work with Microsoft to determine how embedded IVAS instrumentation can be used to support test and evaluation efforts.
5. Determine how IVAS and the RTA capability can integrate into or replace existing real time casualty assessment instrumentation for training and testing (i.e., MILES).

Joint Air-to-Ground Missile (JAGM)

Executive Summary

- The Joint Air-to-Ground Missile (JAGM) IOT&E I and LFT&E were adequate to assess the operational effectiveness, operational suitability, lethality, and cybersecurity of JAGM when employed by an AH-64E Apache.
- JAGM exceeded hit performance in 87 test shots, which included safety of flight, developmental, integration, and operational testing against a variety of targets. The missile successfully engaged and disabled heavy and light armor, structures, personnel in the open, maritime targets, and classified counterinsurgency targets.
- JAGM allowed pilots to engage targets beyond the capability of HELLFIRE Romeo. The dual guidance section allows the missile to mitigate the effects of battlefield obscurants such as smoke, dust, and foliage that limit the performance of laser designation needed for HELLFIRE Romeo.
- JAGM exceeded reliability requirements. This assessment includes prelaunch and inflight reliability. The program is continuing to improve environmental protection to ensure it is available in all operational environments.
- JAGM did not meet interoperability requirements for its second threshold platform. The Marine Corps AH-1Z was not able to enter JAGM operational testing due to software errors on the aircraft discovered during developmental and integration testing.

System

- JAGM is an air-to-ground, precision-guided missile with two new seekers that replicate and combine the capabilities of the existing laser-guided HELLFIRE Romeo and radar-guided Longbow HELLFIRE missiles.
- The JAGM design combines two sensor technologies – semi-active laser and millimeter wave (MMW) radar – into a single seeker and guidance system while leveraging the HELLFIRE Romeo warhead, motor, and flight control systems. The dual-seeker engagement modes optimize missile performance while minimizing aircraft exposure to enemy observation and fire by:
  - Destroying targets concealed by countermeasures or obscurants
  - Providing target location updates to an inflight missile
  - Minimizing alerts to enemy vehicles of imminent attack and unwanted collateral damage
  - Rapid engagement of multiple targets
- The integrated blast and fragmentation sleeve warhead detonates with a programmable delay fuse and a height of burst feature. This flexibility allows JAGM to destroy heavy armored vehicles while effectively targeting personnel in the open. The programmable fuse enables complete penetration into buildings, bunkers, or lightly armored vehicles prior to detonation.

Mission

Army and Marine Corps commanders employ JAGM from rotary-wing and unmanned aircraft to engage enemy combatants in stationary and moving armored and unarmored vehicles, within complex building and bunker structures, in small boats, and in the open.

Major Contractor

Lockheed Martin Corporation, Missiles and Fire Control Division – Orlando, Florida

Activity

- The Army conducted operational and live fire testing in accordance with the DOT&E-approved Test and Evaluation Master Plan, LFT&E Strategy, and test plans.
- The JAGM program has experienced no operational testing or milestone decision delays due to the effects of the coronavirus (COVID-19) pandemic. Some developmental and integration test events have shifted, but the program remains on schedule.
- The JAGM program completed 87 test shots, which included safety of flight, developmental, integration, and operational testing against a variety of targets. JAGM has successfully

engaged and disabled heavy and light armor, structures, personnel in the open, maritime targets, and classified counterinsurgency targets such as truck and motorcycles.
- The Army Test and Evaluation Command conducted an IOT&E I from March 25 through May 10, 2019, at Fort Hood, Texas, and Eglin AFB, Florida, using an AH-64E. Operational pilots fired six missiles in all JAGM engagement modes against stationary and moving maritime and land targets in daytime conditions demonstrating that suboptimal terminal trajectory can degrade lethality against maritime targets. The Army subsequently updated the software, adjusted the terminal trajectory angle, and conducted additional maritime testing in 1QFY20 and 2QFY20 demonstrating improved JAGM lethality against maritime targets.
- In December 2019, the Navy began integration testing with JAGM and the AH-1Z Viper in preparation for an IOT&E scheduled for 2QFY20. Integration testing revealed that that the software for the AH-1Z and the aircraft's Target Sight System (TSS) were not ready for the upcoming IOT&E.
- In February 2020, the Navy decided to delay operational testing using the AH-1Z to focus on developing a new TSS software build. The Navy projects to have an effective TSS software build to support further JAGM integration testing in 1QFY21.
- In 4QFY21, using the AH-1Z, the Navy completed JAGM live fire testing against a multi-story structure, a multi-room structure, and against personnel behind a triple brick wall.
- The inability for the Navy to validate the AH-1Z as a threshold platform led to an Army decision in July 2020 to delay the JAGM Full-Rate Production decision to 4QFY21, following the completion of a Navy IOT&E using the AH-1Z. In the interim, the Army will continue with low-rate initial production of JAGM.

Assessment

- The Army testing was adequate to assess the operational effectiveness, operational suitability, lethality, and cybersecurity of JAGM when employed from an AH-64E.
- JAGM did not meet interoperability requirements with its second threshold platform. The Marine Corps AH-1Z was not able to progress to the planned JAGM IOT&E due to software errors on the aircraft discovered during developmental and integration testing.
- The Navy is focused on resolving the software concerns with the AH-1Z and intends to complete JAGM IOT&E II with the AH-1Z threshold platform in 3QFY21.

Operational Effectiveness

- The Army developed an effective and efficient pilot-vehicle interface that was intuitive for operational pilots.
- Aircrews can employ JAGM in multiple engagement modes depending on the tactical situation. This flexibility increases options for aircrews in the evolving operational environment in combat.
- JAGM allows pilots to engage targets not possible using HELLFIRE Romeo. The dual guidance capability mitigates the effects of battlefield obscurants such as smoke, dust, and foliage that limit the performance of legacy semi-active laser HELLFIRE missiles.
- JAGM affords improvements over the legacy Longbow HELLFIRE by providing a regret avoidance capability. This feature allows a missile using millimeter wave radar to be redirected in flight. Regret avoidance allows the aircrew control of a missile throughout its flight to avoid fratricide or collateral damage.
- JAGM has exceeded required hit performance in operationally realistic testing against a variety of targets.

Operational Suitability

- JAGM exceeds prelaunch and inflight reliability requirements. The program is using lot acceptance inspections to assess continuing environmental protection improvements to ensure JAGM is reliable in all operational environments.
- JAGM has completed environmental testing in a chamber but has not been flight tested in extreme cold environments. Flight missile testing in an operationally representative arctic environment, such as Alaska, may present performance limitations not possible in a static chamber environment.
- JAGM does not have a captive aircrew training missile. This training device is needed to ensure aircrews are prepared to employ JAGM.

Lethality

- JAGM demonstrated adequate lethality against heavy and light armor, structures, personnel in the open, maritime targets, and classified counterinsurgency targets. The height of burst is higher than expected when engaging personnel in the open and appears unrelated to surrounding objects or vehicles.
- The new terminal trajectory angle resulted in improved hit point selection and lethality against maritime targets.
- Preliminary assessment indicates JAGM lethality as fired from AH-1Z against multi-room structures is comparable to legacy HELLFIRE. The Navy did not demonstrate lethality against personnel behind a triple-brick wall due to a problem with fuse delay timing. Correction of the timing should result in JAGM lethality at least equal to that of HELLFIRE. The Navy did not demonstrate lethality against the multi-story building due to a warhead failure that is currently under investigation by the Program Office.

Cybersecurity

- The cybersecurity of JAGM has been assessed against insider and nearsider threats. Details are available in the classified JAGM IOT&E report published in August 2020.
- The Army has not assessed JAGM cybersecurity of the supply chain or against an outside threat.

Recommendations

- The Navy should:
  1. Complete the interoperability and cybersecurity testing of the JAGM employed from the AH-1Z.
  2. Address the failures encountered in live fire testing.

- The Program Office should:
  1. Investigate the cybersecurity of the JAGM supply chain.
  2. Correct issues with the height of burst sensor and adjust tactics, techniques, and procedures to ensure lethality against personnel in the open.
  3. Demonstrate JAGM lethality against emerging threats.
  4. Continue to improve reliability through lot acceptance and reliability testing.
  5. Conduct missile flight testing in the arctic to assess the effects of sustained extreme cold temperatures.
- The Army should:
  1. Develop, test, and field a captive aircrew training missile with appropriate supporting training materials.

Joint Assault Bridge (JAB)

Executive Summary

- The Army conducted the first IOT&E of the Joint Assault Bridge (JAB) at Fort Bliss, Texas, on April 2 – 29, 2019. Because of the system's poor reliability during the IOT&E, the Program Executive Officer (PEO), as the Milestone Decision Authority, deferred the Full-Rate Production decision. The PEO intends to fix reliability issues and conduct a second IOT&E.
- The Army conducted the second IOT&E November 13 – 23, 2020. The DOT&E will determine operational effectiveness, operational suitability, and survivability for JAB following the second IOT&E.
- In FY20, the Army verified, through testing, that the Automatic Fire Extinguishing System updates and armor integration design changes successfully mitigated some of the vulnerabilities identified during the 2018 JAB LFT&E.
- The Program Office continues to work on improving the bridge launching mechanism and hydraulic power unit designs to mitigate additional vulnerabilities identified during the 2018 JAB LFT&E. These changes will be incorporated and validated through testing in FY21.

System

- The JAB replaces the Wolverine and M48/M60 chassis-based Armored Vehicle Launched Bridge (AVLB) systems in the Armored Brigade Combat Team (ABCT) Brigade Engineer Battalions and in the Mobility Augmentation Companies or Combat Engineer Companies.
- The design concept includes a M1A1 Abrams chassis with M1A2 heavy suspension, and a contractor-designed, integrated hydraulic bridge launch mechanism, and the existing Heavy Assault Scissor Bridge currently used by the AVLB. The Army intends the design to improve survivability and provide enhanced mobility ensuring freedom of maneuver, improved supportability, and enabling use of common battlefield communication suites.

- The Army assumed the lead for the JAB program in 2010 after the Marine Corps canceled the program due to cost and performance concerns.
- The JAB is an Acquisition Category II program with an acquisition objective of 297 systems.

Mission

Commanders employ JAB to enable the ABCT to close with and destroy the enemy by maneuvering over natural and man-made obstacles that would otherwise prevent freedom of maneuver.

Major Contractors

- Leonardo DRS Technologies, Inc. – St. Louis, Missouri
- Anniston Army Depot – Anniston, Alabama

Activity

- All testing was conducted in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plans.
- The Army conducted the first JAB IOT&E at Fort Bliss, Texas, April 2 – 29, 2019. The test unit consisted of Armored and Engineer elements from 2nd Brigade, 1st Armored Division. Test event included combined-arms and in-stride breaching operations. In addition, the Army conducted a cybersecurity adversarial assessment.
- The Army planned to execute a second JAB IOT&E at Fort Riley, Kansas, in June 2020. The test was rescheduled to November 13 – 23, 2020, due to coronavirus (COVID-19) pandemic restrictions.
- The Army conducted a JAB tactics, techniques, and procedures (TTP) demonstration event with troops at Yuma Proving Ground (YPG), Arizona, February 11- 21, 2020. The demonstration was supported by soldiers from the JAB IOT&E 2 test unit in Fort Riley, Kansas. Product Manager (PM) Bridging led the demonstration, while the U.S. Army Test and Evaluation Command (ATEC) executed and analyzed the results. ATEC reported the trends of the updated system

design and provided an entrance risk assessment for JAB IOT&E 2. The user developed procedures and training packages for launching and retrieving the JAB system over combat obstacles at the event.

- In 2QFY20, the Army completed follow-on live fire testing to confirm that the design changes to the Automatic Fire Extinguishing System and armor integration mitigated the vulnerabilities identified during the JAB LFT&E completed in 2018.
- The Program Office continues to work on improving the bridge launching mechanism and hydraulic power unit designs to mitigate additional vulnerabilities identified during the 2018 JAB LFT&E. These changes will be incorporated and validated through testing in FY21.

Assessment

- Because of the system's poor reliability during the first IOT&E, the PEO, as the Milestone Decision Authority, deferred the Full-Rate Production decision. The PEO intends to fix reliability issues and conduct a second IOT&E. DOT&E plans to determine operational effectiveness, operational suitability, and survivability for JAB following IOT&E 2.
- The JAB demonstrated the capability to cross anti-tank ditches using a variety of techniques during the February 2020 TTP Demonstration event with troops at YPG. The JAB demonstrated an improved readiness rate over the readiness rate from IOT&E 1. The Army used the JAB demonstration event to refine their Doctrine and Tactics Training package. Their refinement will improve the quality of training provided to the unit before IOT&E 2.
- The Automatic Fire Extinguishing System updates and armor integration design changes successfully mitigated some of the vulnerabilities identified during the 2018 JAB LFT&E.

Recommendation

1. The Army should continue to correct vulnerabilities identified in JAB live fire testing to increase the ability of the unit equipped with JAB to continue to conduct its mission after a combat engagement.

M109 Family of Vehicles (FoV) Paladin Integrated Management (PIM)

Executive Summary

- The Army conducted the Paladin Integrated Management (PIM) Breech Reliability and High Angle Modular Artillery Charge System (MACS) 5H test from January 30 through February 8, 2020, at Yuma Proving Ground, Arizona.
- Self-Propelled Howitzer (SPH) Phase one and two breech parts demonstrated improved breech reliability. The Army started incorporating the redesigned breech components across the fleet.
- The Army may need to stockpile spare legacy breech and cannon-related parts to support operations in a high intensity environment until sufficient production exists for the new breech and firing train components.
- Following the award of the Full-Rate Production contract to BAE Systems in January 2020, the program achieved the production goal of eight systems per month, implemented system software updates, and completed upgrades to system technical manuals.
- The program plans to execute several modifications from 3QFY23 to 2QFY25 to mitigate adverse effects from underbody blast events. The modifications include floor mat retention brackets that are part of the FY24 PIM production, and a series of modifications to improve projectile stowage security.
- The PIM program anticipates achieving Full Material Release in July 2022, and Full Operational Capability in 2034.

System

- The M109 Family of Vehicles (FoV) PIM program consists of two vehicles: the SPH and Carrier Ammunition Tracked (CAT) resupply vehicle.
  - The M109A7 SPH is a tracked, self-propelled 155 mm howitzer designed to improve sustainability maneuverability over the legacy M109A6 howitzer. The Army is updating some of the breech components based upon results from testing in the second IOT&E and the breech reliability/high angle test in early 2020.
  - The M992A3 CAT supplies the SPH with ammunition. The ammunition carriers have a chassis similar to the SPH. The ammunition carriers are designed to carry 12,000 pounds or 98 rounds of ammunition in various configurations. A crew of four soldiers operates the CAT.
  - The Army will equip the SPH and CAT with two armor configurations to meet two threshold requirements for force protection and survivability – Threshold 1 (T1) and Threshold 2 (T2).

  - The base T1 armor configuration is integral to the SPH and CAT. The Army intends the T2 configuration to meet protection requirements beyond the T1 requirement with add-on armor kits.
  - The Army plans to employ PIM vehicles in the T1 configuration during normal operations and will equip the SPH and CAT with T2 add-on armor kits during combat operations.
- The Army designed an underbody kit to determine the potential protection an SPH and CAT could provide against IEDs similar to those encountered in Iraq and Afghanistan. The Army purchased five underbody kits for test purposes. The Army does not intend to equip the SPH or CAT with the underbody kit at this time.
- The Army intends to employ the M109 FoV as part of a Fires Battalion in the Armored Brigade Combat Team and Artillery Fires Brigades. The Army plans to field up to 689 sets of the M109 FoV.

Mission

Commanders employ field artillery units equipped with the M109 FoV to destroy, defeat, or disrupt the enemy by providing integrated, massed, and precision indirect fire effects in support of maneuver units conducting unified land operations.

Major Contractor

BAE Systems – York, Pennsylvania

Activity

- The Army conducted developmental testing throughout 2019 to address breech reliability fixes. The final configuration, including modifications to the firing mechanism, breech spring packs, cam and roller, and block stop and carrier plunger, completed its final breech reliability testing as a follow-on test event with soldier crews in February 2020 at Yuma Proving Ground, Arizona. The breech reliability testing addressed missions not fired during the IOT&E, such as firing the MACS 5H at high quadrant elevation.
- The Army is finalizing production plans to mass-produce the modified breech components to support implementation efforts in the field and provide necessary spare parts.
- The Army is investigating a slide block breech for the M109A7 to replace the current breech.
- The Army updated technical manuals and training consistent with recommendations from previous operational testing and validated those changes during the breech reliability test at Yuma Proving Ground in February. The changes addressed recurring on-board preventive maintenance tasks and operating techniques to ensure consistent and reliable functioning of the breech and its subcomponents when firing the MACS 5H propelling charge.
- The program plans to execute several modifications from 3QFY23 to 2QFY25 to mitigate negative effects from underbody blast events. The modifications include floor mat retention brackets and a series of modifications to improve projectile stowage security that are part of the FY24 PIM production.
  - The floor mat retention improvement ensure that the floor mats stay on the floor and not become airborne during underbody blast events.
  - The program will implement a Vertical Ammunition Cover to retain stowed rounds.
  - The program developed an improved J-hook latch for ammunition retention. This heavier latch is part of the FY22 production cut-in and will be incorporated into the Extended Range Cannon Artillery (ERCA).
  - The compartment portion of the turret provides space for projectile stowage and what are known as oddment trays. The program is developing an engineering change proposal to reinforce the securing devices for the projectiles and trays. All of these changes will carry over to the ERCA Increment 1 platform that leverages the PIM turret.
- The current program schedule shows Production Verification Testing starting in December 2020 with completion in May 2021.
- The PIM program anticipates achieving Full Material Release in July 2022 and Full Operational Capability in 2034.

Assessment

- The SPH and CAT are operationally effective. A field artillery unit equipped with the SPH provided accurate artillery fires and conducted movement and manever sufficient to keep pace with an Armored Brigade Combat Team.
- In operational testing, both the CAT and SPH showed significant improvement over the speed and maneuverability demonstrated by the legacy ammunition carrier and howitzer.
- The CAT resupply vehicle is suitable. The CAT exceeded its reliablity and availability requirement. The SPH is operationally suitable when firing MACS charges up through charge 4H.
- The SPH has improved when firing MACS charge 5H for enviroments requiring greater ranges.
  - Since the IOT&E, the Army implemented a two-phased approach to correct legacy breech reliability failures. Phase one addressed subcomponents of the legacy breech; phase two included more comprehensive design changes for the gun mount and cradle. Neither phase changed the basic breech design.
  - The results from the Yuma Proving Ground test indicate that the breech modifications improved the reliability of the breech when firing the MACS 5H propelling charge consistent with realistic combat firing mission operations.
- The crew compartment Automatic Fire Extinguisher System (AFES) in the SPH was designed to protect a small, localized area and is deficient in providing adequate fire survivability. The Program Office is modifying the crew compartment AFES to improve SPH crew survivability to fires.

Recommendations

The Army should:

1. Continue to implement across the fleet, the final design changes, and subcomponent modifications to address breech reliability shortcomings when firing MACS 5H.
2. Continue to examine a slide block breech for the M109A7.
3. Finalize production plans for the modified breech components and consider stockpiling breech parts with deployed artillery units or prepositioned fleets until receipt of component modifications and their installation
4. Correct the deficiencies in the SPH's crew compartment AFES and validate those fixes in test.

M1158 7.62 mm Cartridge

Executive Summary

- Forces will use the M1158 cartridge, fired by the M240 series of machine guns, to defeat targets with improved lethality compared to the current M80A1 and M993 cartridges.
- The Army began M1158 low-rate initial production in 3QFY19 and completed the M1158 live fire lethality testing in 4QFY20.

System

- The 7.62-mm M1158 cartridge will replace the current M993 7.62-mm armor-piercing cartridge in the M993-linked configuration to provide improved lethality compared to the current M80A1 and M993 cartridges.
- The M1158 cartridge is compatible with the M240 series of machine guns; the Mk 48 machine gun; and the M110 series, Mk 17, Mk 14, and M14 series rifles.
- The M1158 utilizes a core and penetrator encapsulated in a reverse-drawn copper jacket.

Mission

Forces equipped with weapons that fire the M1158 will engage enemy combatants during tactical operations in accordance with applicable tactics, techniques, and procedures to accomplish assigned missions with greater lethality.

Major Contractors

- Picatinny Arsenal, New Jersey
- Olin Winchester – Independence, Missouri

Activity

- The Army completed initial live fire testing of the M1158 in March 2019 to support urgent materiel release (UMR). The Army began low-rate initial production in May 2019 and approved UMR in October 2019.
- In 2QFY20, the Army approved the M1158 Milestone C and Type Classification Standard.
- The coronavirus (COVID-19) pandemic restrictions disrupted M1158 low-rate initial production and delayed live fire testing by 5 months. The Army completed live fire testing in 4QFY20.
- The Army used barrier-protected gelatin targets to enable credible computer modeling of M1158 performance. The Army conducted tests against various light material barriers and other targets to determine the projectile's ability to perforate operationally relevant targets. Testing was conducted in accordance with the DOT&E-approved LFT&E plan.
- The Army plans approval of M1158 for Full Material Release in 2QFY21.

Assessment

Analysis of M1158 lethality test results is ongoing. In FY21, DOT&E will report on the M1158 performance in a classified lethality report to support a Full-Rate Production decision in 3QFY22.

Recommendations

None.

Precision Strike Missile (PrSM)

Executive Summary

- The Precision Strike Missile (PrSM) is a surface-to-surface missile that will provide commanders with all-weather, cluster-munition-compliant capability to attack critical and time-sensitive area and point targets.
- The PrSM is required to engage targets at extended ranges in all weather conditions exceeding the Army Tactical Missile System (ATACMS) missile's maximum range of 300 kilometers.
- The Army intends to begin Engineering and Development Tests in 3QFY21 followed by production qualification tests against representative target arrays in 1QFY23.

System

- The PrSM is:
  - A surface-to-surface missile that will provide commanders with an all-weather, cluster-munition-compliant capability to attack critical and time-sensitive area and point targets
  - Part of the Multiple Launch Rocket System (MLRS) Family of Munitions (MFOM) that will complement the current suite of Guided MLRS rockets and replace ATACMS
  - Required to engage targets at extended ranges in all weather conditions exceeding the ATACMS maximum range of 300 kilometers
- The PrSM launch pod missile container holds two missiles instead of a single ATACMS missile.
- Future PrSM increments will concentrate on increasing the range and engagement of time-sensitive, moving, hardened, and fleeting targets.
- Army units will fire the PrSM missiles from the tracked M270A2 MLRS and the wheeled M142 High Mobility Artillery Rocket System (HIMARS).

Mission

Commanders will use the PrSMs to provide the supported Joint Force Commander with a 24/7, all weather capability to attack critical and time-sensitive area and point targets within the multi-domain battlefield.

Major Contractor

Lockheed Martin Missiles and Fire Control – Grand Prairie, Texas; assembled in Camden, Arkansas

Activity

- This is the first Annual Report article for this program.
- On July 14, 2016, DOT&E approved the Long Range Precision Fires (LRPF) missile Milestone A Test and Evaluation Master Plan (TEMP).
- On March 31, 2017, the LRPF Milestone A Acquisition Decision Memorandum authorized entering the Technology Maturation and Risk Reduction (TMRR) phase with competitive prototyping.
- The Army awarded TMRR contracts to Lockheed Martin and Raytheon Missile Systems to conduct successful prototype flight tests by March 2020 that included prototype missile performance through flight trajectory to warhead detonation, warhead performance, interoperability with the HIMARs launcher, and demonstration of system software.
- In early 2018, the Army changed the program name from LRPF to PrSM to avoid confusion during the establishment of the Army Long Range Precision Fires Cross-Functional Team.
- On December 21, 2018, the Commanding General of Army Futures Command validated the PrSM Capability Development Document-Abbreviated (CDD-A) and directed fielding beginning in 1QFY23 as an early operational capability.
- Lockheed Martin completed three successful prototype flight tests between December 2019 and April 2020. All

three Lockheed Martin prototype missiles demonstrated compatibility with the HIMARS launcher and nominal test flights including egress from launcher, trajectory to target, and warhead detonation.

- Due to technical issues during component testing, Raytheon Missile Systems did not complete the required prototype flight tests by March 2020 and withdrew from the TMRR phase competition.
- On December 20 2019, the Army awarded Lockheed Martin the sole contract for the Enhanced Technology Maturation and Risk Reduction phase.
- The Army is currently updating the PrSM Increment 1 CDD to increase the missile's objective maximum range.
- The Army intends to conduct a limited user test in 3QFY23 and an IOT&E in 4QFY24.
- The Army expects to achieve an early operational capability in FY23 and an Initial Operational Capability in 4QFY25.

Assessment

DOT&E is working with the Army to find a test location that can accommodate PrSM test flights against targets at greater ranges. The Army is examining various options for testing the missile at extended ranges inside the U.S that includes firing a PrSM missile at an extended range into the ocean in 4QFY21.

Recommendation

1. The Army should continue to explore long-range flight corridors to facilitate the evaluation of the operational effectiveness of the PrSM against targets at greater ranges in an operational environment.

RQ-7Bv2 Block III SHADOW – Tactical Unmanned Aircraft System

Executive Summary

- The Army completed the RQ-7Bv2 Block III Shadow FOT&E II totaling over 400 flight hours at Fort Bliss, Texas, in September and October 2020. Initial findings can be assessed on early test observations. The data analysis is ongoing and will be published in a future FOT&E II report.
- A major wiring and power issue was discovered when mating the Shadow vehicle-mounted ground control station (GCS) to the Joint Light Tactical Vehicle (JLTV). The JLTV was not configured to support GSC compatibility resulting in a wiring and power issue causing excessive smoke that the program must address.
- Initial user feedback on the new Shadow Electro-Optical (EO)/Infrared (IR) Laser Designator (SHEILD) payload is positive. The image quality is exceptional when compared to the legacy Plug-in Optronic Payload 300 on earlier versions of the RQ-7B Shadow.
- The Army demonstrated the ability to establish manned-unmanned teaming (MUMT) connectivity between the Shadow and both the AH-64E Version 6 and AH-64D during FOT&E II. The assistance of program experts at the FOT&E test site enabled successful MUMT connectivity by assisting in refinement of local procedures. Current training and reference materials for the employment of the MUMT, for both manned and unmanned aircrews, are not adequate and do not posture crews for success. The Army should take a multi-system approach to improve MUMT connectivity.
- The Shadow has not been tested in a contested environment with an active electronic warfare threat. The program manager acknowledges this test limitation and will continue to search for capability improvements.

System

- The RQ-7Bv2 Shadow Block III is a modernization of the RQ-7Bv2 fielded to the Army in 2014. The Block III is a grouping of engineering changes developed since the introduction of the RQ-7Bv2. These changes are designed to increase reliability, reduce maintenance burden, and improve operational effectiveness.
- The RQ-7BV2 Shadow Block III provides 16 hours of continuous coverage within a 24-hour period, with capability of surging to 24-hours continuous coverage for a 72-hour surge coverage period. The maximum range is 125 kilometers with a maximum ceiling of 15,000 feet mean sea level (MSL). The Shadow will generally operate between 8,000 to 10,000 feet above ground level during the day and 6,000 to 8,000 feet above ground level at night.
- Shadow RQ-7Bv2 Shadow Block III improvements include:
  - New more powerful and more reliable engine
  - Improved propeller design that increases power while reducing noise signature
  - Redesigned muffler to reduce noise signature
  - New more powerful mission processing computer; Small Mission Computer (SMC)
  - Very High Frequency (VHF) and Ultrahigh Frequency (UHF) radio communications
  - Improved sensor payload; SHEILD
  - Improved environmental protection/weatherization
  - Improvements to structural components to account for increase weight
- The RQ-7B Shadow Block III needs an improved surface to serve as a runway. The aircraft is launched using a hydraulic/pneumatic launcher and is recovered on a runway using the Tactical Automatic Landing System. The Shadow can recover on a short runway by using an arresting cable/arresting hook system.

Mission

RQ-7B Shadow Block III provides Commanders with increased situational awareness, improved wide-area target acquisition, and high-value target tracking to conduct both shaping and decisive operations. The system conducts manned-unmanned teaming with the AH-64D/E to designate targets for air-to-ground missile engagements.

Major Contractors

- Unmanned Aerial System: Textron Systems – Hunt Valley, Maryland
- Sensor Payload: L3 Harris WESCAM – Burlington, Ontario, Canada

Activity

- The Army conducted all testing in accordance with a DOT&E-approved Test and Evaluation Master Plan and test plan. The RQ-7Bv2 Block III Shadow FOT&E II was conducted at Fort Bliss, Texas, in September and October 2020.
- The RQ-7Bv2 Block III Shadow program has experienced no operational testing or milestone decision delays due to the effects of the coronavirus (COVID-19) pandemic. Some developmental and integration test events have shifted, but the program remains on schedule.
- The Program Office began integration testing of the new SHEILD payload in October 2019 at Dugway Proving Grounds, Utah. Integration testing with the SHEILD payload completed in November 2019 with the payload completing 45.6 operational hours.
- The Shadow completed environmental, Electromagnetic Environment Effects (E3), and transportability testing at Redstone Test Center, Alabama, during November and December 2019.
  - Environmental testing was completed in a test chamber to assess the aircraft's improved weatherization.
  - E3 testing is done to determine the vulnerabilities of equipment to ambient natural and manmade electromagnetic activity.
  - Transportability testing assessed the aircraft ability to withstand the impact shocks associated with tactical ground movement.
- The Program Office completed two software updates in FY20 in preparation for FOT&E II. Software build 6.2 was released in February 2020 to address communication relay and improvements to the tactical automatic landing system. Software build 6.3 was released in May 2020 to address engine control unit issues. Software build 6.3 is the system under test for FOT&E II.
- The Army planned to conduct developmental and integration testing with the AH-64E Version 6 at Dugway Proving Grounds, Utah, in March and April 2020 to assess the Shadow's ability to conduct manned-unmanned teaming. This developmental and integration testing was postponed due to COVID-19, but completed in July 2020 in preparation for FOT&E II.

Assessment

- The RQ-7Bv2 Block III accumulated over 400 flight hours during FOT&E II conducted at Fort Bliss, Texas, in September and October 2020. Reliability assessments are ongoing and results will be published in a future FOT&E II report.
- The Army demonstrated the ability to establish MUMT connectivity between the Shadow and both the AH-64E Version 6 and the AH-64D during FOT&E II. The Army has not developed a standard procedure for establishing MUMT connectivity. Successful MUMT operations require coordination between unit subject matter experts to develop local tactics, techniques, and procedures. The Army should document and codify procedures required to establish connectivity for the Shadow operating with the AH-64D and the AH-64E.
- Initial user feedback on the new SHEILD payload is positive. The image quality is exceptional when compared to the legacy Plug-in Optronic Payload 300 on earlier versions of the RQ-7B Shadow. A final suitability assessment and user surveys will be published in a future FOT&E II report.
- The SHEILD payload will allow for the development of new tactics, techniques, and procedures through new capabilities, such as the picture-in-picture function and other pilot-vehicle-interface improvements.
- The RQ-7Bv2 Block III Shadow includes multiple improvements designed to reduce audio signature of the aircraft at operational altitudes. Initial test site observations support developmental test findings on effectiveness of design changes. A final determination will be made in the FOT&E II report.
- A major wiring and power issue was discovered when mating the Shadow vehicle-mounted GCS to the JLTV. The JLTV was not configured to be compatible with the GCS resulting in a wiring and power issue causing excessive smoke that the program must address.
- The Shadow has not been tested in a contested environment with an active electronic warfare threat. The program manager acknowledges this test limitation and will continue to search for capability improvements.

Recommendations

- The Army should:
  1. Determine compatibility of the JLTV wiring the Shadow GCS and the potential risk across other truck mounted systems.
  2. Develop and codify in procedures for establishing MUMT connectivity with the AH-64D and the AH-64E.
- The program manager should:
  1. Plan and conduct electronic warfare testing to better understand system survivability in a contested environment.

Soldier Protection System (SPS)

Executive Summary

- The Soldier Protection System (SPS) consists of four subsystems: Vital Torso Protection (VTP); Torso and Extremity Protection (TEP); Integrated Head Protection System (IHPS); and Military Combat Eye Protection (MCEP). Each subsystem has its own acquisition strategy.
- The SPS TEP, Generation II VTP, IHPS, and MCEP met ballistic requirements.
- In 4QFY20, the Army completed First Article Testing of eight new, lighter-weight Generation III VTP designs (four torso plate and four side plates). The Army plans to further test the revised designs of the two lighter-weight VTP designs that did not meet ballistic requirements.

System

- The SPS is a suite of personal protection subsystems intended to, at a reduced weight, provide equal or increased levels of protection against small-arms and fragmenting threats compared to existing personal protection equipment. The SPS subsystems are designed to protect a soldier's head, eyes, and neck region; the vital torso and upper torso areas, as well as the extremities; and the pelvic region. The SPS is a modular system and provides soldiers the capability to configure the various components into different tiers of protection depending on the threat and the mission.
- The SPS consists of four subsystems:
  - TEP consists of the soft armor Modular Scalable Vest (MSV) with provision for adding the Ballistic Combat Shirt (BCS) for deltoid and extremity protection and the Blast Pelvic Protector (BPP) for pelvic and femoral artery protection.
  - VTP consists of front and rear hard armor torso plates (either the Enhanced Small Arms Protective Insert (ESAPI) or the X Threat Small Arms Protective Insert (XSAPI)) and the corresponding hard armor side plates (either Enhanced Side Ballistic Insert (ESBI) or the X Threat Side Ballistic Insert (XSBI)).
  - IHPS consists of a helmet, with provision for adding a mandible and/or visor for mounted use.
  - MCEP is a selection of protective eyewear validated for use by Army personnel. The Army's Authorized Protective Eyewear List includes all authorized protective eyewear.
- Soldiers currently receive SPS components through the Army Rapid Fielding Initiative. The Army plans to field the complete SPS to the Close Combat Force, which includes Infantry, Engineers, and Scouts with habitual attachments (i.e., combat medics, forward observers). The Army plans to subsequently field SPS to the broader Army as quantities are available.

Mission

Units will accomplish assigned missions with soldiers wearing the SPS that provides protection against injury from a variety of ballistic (small-arms and fragmenting) threats.

Major Contractors

- TEP Full-Rate Production Vendors/Designs (Multiple vendors to stimulate competition and achieve best price through Fair Opportunity awards):
  - Armor Express – Eden, North Carolina (MSV, BPP)
  - Bethel Industries Inc. – Jersey City, New Jersey (MSV, BPP)
  - Point Blank Enterprises, Inc. (Protective Apparel & Uniform) – Pompano Beach, Florida (BCS)
  - Carter Enterprises Industries Inc. – Brooklyn, New York (BCS)
  - Eagle Industries Unlimited – Virginia Beach, Virginia (BCS)
- VTP Low-Rate Initial Production Vendors:
  - Engense Armor Systems – Camarillo, California (ESBI)
  - Florida Armor Group – Miami Lakes, Florida (ESBI)
  - Leading Technology Composites – Wichita, Kansas (ESAPI, ESBI)
  - TenCate Armor – Hebron, Ohio (ESAPI, XSBI)
  - Avon/Ceradyne – Irvine, California (ESAPI, XSAPI, XSBI)
- IHPS Vendor:
  - Avon/Ceradyne – Irvine, California

Activity

- The development, testing, and production/fielding of the four SPS subsystems (TEP, VTP, IHPS, and MCEP) have been on different timelines. The Army made a Full-Rate Production decision for the TEP in September 2016 and the IHPS in October 2018. The Army completed Generation II VTP testing in February 2018. Each SPS subsystem is compatible with existing (legacy) personal protective equipment (for example, soldiers can use existing hard armor plates in the new MSV). DOT&E had no MCEP-related activity in FY20.
- The Army completed First Article Testing of three lighter-weight ESAPI and one lighter-weight XSAPI Generation III torso plate designs and three lighter-weight ESBI and one lighter-weight XSBI Generation III side plate design in 4QFY20. Upon completion of testing against additional ballistic threats in 2QFY21, the Army intends to make a subsequent Full-Rate Production decision on these lighter-weight VTP designs.
- The Army plans to complete additional full-up system-level testing of the SPS (with all subsystems combined) against additional threats in 2QFY21.
- The Army is testing VTP ballistic performance in accordance with DOT&E-approved test plans.
- The Aberdeen Test Center, Maryland, implementation of coronavirus (COVID-19) pandemic safety protocols and procedures resulted in approximately a 2-week delay in VTP testing.

Assessment

- After the first two lighter-weight ESBI designs failed to meet ballistic First Article Testing requirements, the Army revised two criteria for the lighter-weight ESBI. All three submitted designs met the Army's revised ballistic criteria.
- None of the three lighter-weight ESAPI designs initially met ballistic First Article Testing requirements. The Army revised a criterion and two of the three designs (one of which was modified from its original) subsequently met ESAPI ballistic requirements. The Army anticipates testing a revised third design in 1QFY21.
- The lighter-weight XSAPI design submitted for First Article Testing did not meet ballistic requirements. The Army anticipates testing a revised lighter-weight XSAPI design in 1QFY21.
- The lighter-weight XSBI design submitted for First Article Testing met ballistic First Article Testing requirements.
- DOT&E will report on VTP and SPS ballistic performance upon the completion of testing in 2QFY21.

Recommendation

1. The Army should continue the testing of the lighter-weight Generation III VTP designs.

Stryker Family of Vehicles (FoV)

Stryker Anti-Tank Guided Missile (ATGM)

Stryker Common Remotely Operated Weapon Station - Javelin (CROWS-J)

Executive Summary

- DOT&E approved the Test and Evaluation Master Plan (TEMP) Annex and operational assessment test plan for the Stryker Common Remotely Operated Weapon Station – Javelin (CROWS-J) Engineering Change Proposal (ECP) in September 2019. The Army downgraded the operational assessment of the CROWS-J ECP to an early user assessment (EUA) prior to the test start date due to poor system reliability during pre-test events. The Army conducted the EUA at Aberdeen Proving Ground, Maryland, from September 30 through October 11, 2019.
- In 4QFY19, the Army performed two system-level live fire test events in support of a Stryker CROWS-J force protection evaluation. The Army plans to conduct a final live fire test event in 2QFY21.
- The Army plans to conduct an operational assessment of the CROWS-J ECP at Aberdeen Proving Ground, Maryland, in 3QFY21, following the correction and testing of identified failure modes.
- DOT&E approved the Stryker Anti-Tank Guided Missile (ATGM) ECP TEMP Annex and FOT&E test plan in September 2020.
- The Army conducted the Stryker ATGM Modified Improved Target Acquisition System (MITAS) ECP FOT&E at Yakima Training Center, Washington, from September 30 through October 9, 2020. DOT&E plans to publish an FOT&E test report in FY21.

System

- The Stryker Family of Vehicles (FoV) is built on a common chassis, with some variants having different Mission Equipment Packages. There are 18 variants:
  - Ten flat-bottom variants that include the Infantry Carrier Vehicle (ICV), Mobile Gun System (MGS), Reconnaissance Vehicle (RV), Mortar Carrier (MC), Commander's Vehicle (CV), Fire Support Vehicle (FSV), Engineer Squad Vehicle (ESV), Medical Evacuation Vehicle (MEV), ATGM Vehicle, and Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV).
  - Seven Double-V-Hull (DVH) variants for the following: ICV, CV, MEV, MC, ATGM, FSV, and ESV.
  - One configuration of a modified ICV platform integrating a 30-mm cannon.

Stryker ATGM MITAS ECP

- The Army intends the ATGM MITAS ECP to upgrade existing ATGM systems in order to support current and future operational requirements of Stryker Brigade Combat Teams. ATGM MITAS upgrades include:
  - Precision Far Target Locator (pFTL)
  - Network Lethality (NL)
  - Image Enhancement (IE)
  - Color Camera
  - Color Gunners Display
  - Software Improvements (MITAS v3.1)
  - Common Processor-Fire Control System (CP-FCS)
  - Slip-Ring
  - Vehicle Mounted Charger (VMC)
  - Upgraded Tow Missile Launcher (UTML)

Stryker CROWS-J ECP

- CROWS-J ECP builds on the CROWS-J capability fielded to 2nd Cavalry Regiment under an Operational Needs Statement and Directed Requirement.
- The Army intends the Stryker CROWS-J ECP to addresses the obsolescence of the fire control unit (FCU), exchanges the Remote Weapons System (RWS) with the CROWS, enables remote firing of a Javelin missile under armor, improves thermal imaging module (TIM) optics, and

integrates smoke grenade launchers onto the CROWS system.
- The FCU from the RWS will be replaced with a main processing unit (MPU), Weapons Station Control Panel (WSCP), and the Mounted Family of Computing Systems (MFoCS) High Definition (HD) display.
- The CROWS-J will use existing RWS mounting provisions and employ the Javelin launch capability.
- Adapter kits are used to integrate the multiple weapon systems onto the CROWS.

Mission

Units equipped with the Stryker FoV provide Combatant Commanders a medium-weight force capable of rapid strategic and operational mobility to disrupt or destroy enemy military forces, to control land areas including populations and resources, and to conduct combat operations to protect U.S. national interests.

Major Contractors
- General Dynamics Land Systems – Sterling Heights, Michigan; Anniston, Alabama
- Caterpillar – Peoria, Illinois
- Marvin Land Systems – Inglewood, California

Activity
- All testing was conducted in accordance with the DOT&E-approved TEMP and test plan. DOT&E approved changes to the test plan resulting from coronavirus (COVID-19) pandemic safety mitigations.

CROWS-J ECP
- DOT&E approved the Stryker CROWS-J TEMP Annex and operational assessment test plan in September 2019.
- The Army downgraded the operational assessment of the CROWS-J ECP to an EUA due to poor system reliability during pre-test events. The Army conducted the EUA at Aberdeen Proving Ground, Maryland, from September 30 through October 11, 2019.
- The Army is correcting identified failure modes in preparation for an operational assessment of the CROWS-J ECP at Aberdeen Proving Ground, Maryland, in 3QFY21.
- The Army plans to execute a cooperative vulnerability and penetration assessment (CVPA) in June 2021 and an adversarial assessment June through July 2021 at Aberdeen Proving Ground, Maryland.
- The Army performed two system-level live fire test events in 4QFY19 in support of a Stryker CROWS-J force protection evaluation. The Army plans to conduct a final live fire test event in 2QFY21. First fielding is scheduled for 2QFY22. DOT&E plans to publish a joint operational and live fire evaluation report for CROWS-J ECP in FY22.

Stryker ATGM ECP
- DOT&E approved the Stryker ATGM ECP TEMP Annex and FOT&E test plan in September 2020.
- The Army conducted the Stryker ATGM ECP FOT&E and adversarial assessment at Yakima Training Center, Washington, from September 30 through October 9, 2020. DOT&E intends to publish an FOT&E test report in 2QFY21.

Assessment
- Prior to the CROWS-J operational assessment, the CROWS-J demonstrated significant software reliability deficiencies, system integration issues that slowed Javelin engagement times, and Forward Looking Infrared sight problems that led to poor crew target identification performance. This led the test team, with DOT&E concurrence, to downgrade the test to an EUA.
- Preliminary vulnerability assessment of CROWS-J against kinetic threats identified a crew vulnerability related to the vehicle's hatches and will be discussed in the classified survivability assessment.
- Analysis of the Stryker ATGM is ongoing.

Recommendations

The Army should:
1. Address the CROWS-J vulnerability to the kinetic threat as outlined in the classified survivability report.
2. Complete correction and testing of identified failure modes prior to conducting an operational assessment of the CROWS-J ECP.

UH-60V Black Hawk

Executive Summary

- The UH-60V Black Hawk is a digital upgrade to the analog UH-60L Black Hawk that will replace a large portion of the Army's UH-60Ls. The UH-60V design consists of a refurbished UH-60L aircraft, an upgrade to the 2,000 shaft-horsepower T700-GE-701D engine (as part of the UH-60L refurbishment program), multi-function multi-band radios, Blue Force Tracker 2 (BFT2), digital architecture in place of the analog architecture of the UH-60L, and a pilot-vehicle interface (PVI) that is similar to that of the UH-60M.
- The UH-60V performs as well as the UH-60L in executing its external lift mission and meets the external lift Key Performance Parameter. The UH-60V digital cockpit provides pilots with a suite of capabilities for situational awareness and navigation. These capabilities are either similar or superior to those provided on the UH-60M.
- UH-60V completed IOT&E I in September 2019 at Joint Base Lewis McChord, Washington. IOT&E I was not adequate due to the software, hardware, and production process not being production representative.
- The UH-60V was less reliable than fielded UH-60L and UH-60M helicopters during IOT&E I. The UH-60V did not meet its reliability requirements during the 334.5-flight-hour operational test.
- The UH-60V is as survivable as the UH-60L against ballistic, infrared, and laser threats. The UH-60V experienced frequent false radar warnings throughout IOT&E I.
- The UH-60V is vulnerable to insider and nearsider cybersecurity attacks. The system has not been assessed from an outsider cybersecurity threat and for the security of the supply chain.

System

- The Army recapitalized UH-60L to serve as the backbone of the UH-60V. Older UH-60L will be baselined to the Lot 30 configuration, which is the final production version of the UH-60L. The Army will then apply modification kits to finalize the UH-60V production.
- The UH-60V program is a low cost modernization of the UH-60L that the Army intends to produce similar qualities to the UH-60M, such as modernizing the existing UH-60L analog cockpit to a digital cockpit enabling a PVI similar to the UH-60M.
- The program reduces avionics obsolescence and upgrades navigation systems to meet future Global Air Traffic Management instrument flight rule requirements.
- The UH-60V employs an open systems architecture with Army-owned technical data.
- The basic mission configuration includes a crew of four (pilot, copilot, crew chief, and gunner), integral (internal) mission fuel tank, avionics, aircraft survivability equipment, armor protection, two M240 machine guns and ammunition, and other mission-related equipment.

Mission

Commanders will use the UH-60V Black Hawk to conduct air assault, air movement, aerial command and control (C2), and aerial medical evacuation missions. Garrison units equipped with the UH-60V will execute garrison support missions, training and training support, and test support. The UH-60V can be employed individually, in multi-ship formations, or as a company depending on requirements.

Major Contractors

- Development and Engineering: Defense Systems and Solutions – Huntsville, Alabama
- Avionics Enhancements: Northrup Grumman – Woodland Hills, California

Activity

- The Army conducted all testing in accordance with a DOT&E-approved Test and Evaluation Master Plan and test plan. The Army conducted 2019 IOT&E I at Joint Base Lewis McChord, Washington, in September 2019.
- DOT&E approved the Milestone C Test and Evaluation Master Plan and IOT&E I operational test plan using Engineering Development Model (EDM) aircraft with the understanding that UH-60V software build 2.1 was mature and would require minor changes prior to fielding. The UH-60V suffered numerous software reliability issues during IOT&E I. A few software issues, such as those involving the digital moving map, were a frequent occurrence, which in aggregate account for a large number of failures.
- The UH-60V program has been impacted by the coronavirus (COVID-19) pandemic resulting in a delay in IOT&E II from 3QFY20 to 3QFY21. The Program Office is experiencing delays in their instrument flight rules certification process. This certification is required to test a production-representative test article.
- The UH-60V program has been developing software build 3.0 to address software build 2.1 deficiencies identified during developmental testing and IOT&E I. The UH-60V System Integration Laboratory (SIL) has been used throughout developmental testing to confirm software functionality prior to flight testing.
- The program demonstrated developmental software build 3.0 improvements for the Test and Evaluation Working-Level Integrated Product Team (T&E WIPT) using the UH-60V SIL in January 2020.
  - Integration testing for UH-60V software build 3.0 began 2QFY20. Integration testing will ensure that software changes do not adversely affect other UH-60V systems.
  - The Program Office uploaded software build 3.0 onto the UH-60V EDM aircraft in November 2020. The program is using flight testing to ensure improvements developed with the UH-60V SIL are working correctly in an operational aircraft.
- DOT&E published a report evaluating IOT&E I in September 2020.

Assessment

- IOT&E I was not adequate due to the software, hardware, and production process not being production representative.
- UH-60V aircrews were successful in 38 of 42 mission flights during IOT&E I. The UH-60V performs as well as the UH-60L in executing its external lift mission and meets the external lift Key Performance Parameter.
- The UH-60V provides pilots with flight planning and navigation capabilities that are similar to or exceed those provided by the UH-60M.
  - Pilots strongly preferred the UH-60V digital cockpit to the UH-60L analog cockpit.
  - The UH-60V digital cockpit features an integrated digital moving map (DMM) that is displayed on a multi-function display, similar to the UH-60M. The DMM is a major improvement over the paper maps and digital kneeboards available in the UH-60L.
- IOT&E I used UH-60V EDM aircraft that were determined to be not production representative. The EDM aircraft included all UH-60V modifications, but were not produced at the Corpus Christi Army Depot, Texas, production facility using the final production process. Two of the aircraft did not have production-representative wiring harnesses that may have contributed to some reliability failures.
- The Army identified 8 deficiencies and 44 shortcomings with software version 2.1 during developmental testing; additional details are available in the UH-60V IOT&E I Operational Assessment. These software problems were not addressed prior to IOT&E I and contributed to poor suitability findings. Software version 2.1 was used during IOT&E I, despite known deficiencies and shortcomings, due to the lengthy airworthiness certification process. Initial developmental testing has demonstrated that software build 3.0 appears to fix many of the failures observed during IOT&E I in a simulated environment.
  - The UH-60V cockpit software did not function correctly throughout IOT&E I. Software problems distracted pilots during mission execution and forced aircrews to focus inside the aircraft.
  - DMM performance was poor due to software and processor problems. The DMM often loaded slowly and did not keep pace with mission demands.
  - Aircrew knowledge of the test area allowed aircrews to successfully complete missions despite software limitations. The mission success rate would most likely be reduced if reliance on the digital cockpit and navigational systems was necessary to develop situational awareness.
- The UH-60V did not inform aircrews of radar threats during IOT&E I due to frequent false notifications. Several factors contributed to the high false return rate, some may be attributed to the aircraft and some to the test environment's ambient electromagnetic activity (such as cell towers). The EDM aircraft all produced false notifications at differing rates. The sole EDM aircraft production-representative wiring harness had the highest false notification rate. An EDM aircraft with a non-production representative wiring harness was used for signal testing on the radar warning receiver. The use of a non-production representative wiring harness for developmental testing may have contributed to higher false radar warning notifications on the production-representative wiring harness aircraft.
- The UH-60V did not meet its reliability requirements during the 334.5-flight-hour IOT&E I. UH-60V-specific systems failed at a higher rate than corresponding UH 60L-specific systems. Sixty-five percent of reliability failures during the IOT&E I were related to UH-60V-specific systems and components.
- The program has made some cybersecurity improvements. The UH-60V remains vulnerable to insider and nearsider cybersecurity attacks. Cybersecurity vulnerabilities will

have a limited effect on flight safety due to the UH-60V retaining the mechanical flight controls of the UH-60L. More information can be found in the DOT&E IOT&E I Report classified annex.

Recommendations

The Army should:

1. Plan and conduct IOT&E II using production-representative aircraft containing hardware, software, and built using the production-representative processes.
2. Plan future testing in locations unfamiliar to aircrews to emphasize use the digital cockpit and navigational systems to develop situational awareness.
3. Improve and verify software reliability prior to conducting IOT&E II.
4. Verify radar warning receiver by conducting additional developmental testing with production-representative wiring harness design.
5. Plan and conduct an adversarial assessment in conjunction with IOT&E II to assess cybersecurity against an outsider threat and the security of the supply chain.

Navy Programs

Navy Programs

Aegis Modernization Program

Executive Summary

- The Navy continues to modernize the Aegis Weapon System (AWS) on Aegis-guided missile cruisers (CG) and destroyers (DDG) via Advanced Capability Build (ACB)-16 and ACB-20 hardware and software baseline upgrades.
- The Navy continues to test ACB-16 without a DOT&E-approved Test and Evaluation Master Plan (TEMP).
- DOT&E issued an early fielding report on the Navy's FY19 testing of ACB-16 Phase 0 (Baseline 9.A2A cruiser) in March 2020. This report found that the Navy followed the DOT&E-approved test plan and found the 9.A2A cruiser air-defense performance was no better than the performance of previously evaluated Baseline 9 ships; surface warfare performance remains consistent with historical performance. Baseline 9.A2A cruisers were also found to be less suitable than previously evaluated Baseline 9 ships.
- The program delayed ACB-16 Phase 1 (Baseline 9.2.1 destroyer) integrated testing planned for FY20 due to shipyard delays and coronavirus (COVID-19) pandemic travel restrictions. The Navy plans to conduct ACB-16 Phase 1 and Phase 2 (Baseline 9. 2 cruiser and destroyer) operational test events in FY22.
- The Navy continues to develop a modeling and simulation (M&S) suite of the Aegis Combat System in order to assess the Probability of Raid Annihilation requirement for the self-defense mission for Flight III DDG 51 destroyers/ ACB-20.

System

- The Navy Aegis Modernization program provides updated technology and systems for CG 47-class Aegis-guided missile cruisers and DDG 51-class Aegis-guided missile destroyers. This planned, phased program provides similar technology and systems for new construction destroyers.
- The AWS integrates the following components:
  - AN/SPY-1 three-dimensional (range, altitude, and azimuth) multi-function radar
  - AN/SQQ-89 undersea warfare suite that includes the AN/SQS-53 sonar, SQR-19 passive towed sonar array (DDGs 51 through 78, CGs 52 through 73), and the SH-60B or MH-60R helicopter (Flight IIA DDGs 79 and newer have a hangar to allow the ship to carry and maintain its own helicopter)
  - Close-In Weapon System
  - A 5-inch diameter gun
  - Harpoon anti-ship cruise missiles (DDGs 51 through 78, CGs 52 through 73)
  - Vertical Launch System that can launch Tomahawk land-attack missiles, Standard Missile (SM)-2 and SM-6 surface to-air missile variants, Evolved Sea Sparrow Missiles, and Vertical Launch Anti-Submarine Rockets

- The AWS is upgraded through quadrennial ACBs. The Navy is currently upgrading the AWS to ACB-16. ACB 16 Baseline 9.2 upgrades will be installed on modernized and new construction Flight IIA DDG 51 destroyers and Service Life Extension Program for SPY-1B-equipped cruisers and Baseline 8 SPY-1A CG 47 cruisers, respectively. Flight III DDG 51 destroyers will receive ACB-20 Baseline 10.

Mission

The Joint Force Commander/Strike Group Commander employs Aegis-equipped DDG 51-guided missile destroyers and CG 47-guided missile cruisers to conduct:

- Area and self-defense anti-air warfare in defense of the Strike Group
- Anti-surface warfare and anti-submarine warfare
- Strike warfare, when armed with Tomahawk missiles
- Integrated Air and Missile Defense, to include simultaneous offensive and defensive warfare operations
- Operations independently or in concert with Carrier or Expeditionary Strike Groups and with other joint or coalition partners

Major Contractors

- General Dynamics Marine Systems Bath Iron Works – Bath, Maine
- Huntington Ingalls Industries (formerly Northrop Grumman Shipbuilding) – Pascagoula, Mississippi
- Lockheed Martin Rotary Mission Systems – Moorestown, New Jersey

Activity

- DOT&E issued the classified AWS ACB-16 Phase 0 Baseline 9.A2A Early Fielding Report in March 2020.
- The program delayed the FY19-deferred integrated test events within the air warfare mission for ACB-16 variants due to shipyard delays and COVID-19 travel restrictions.
- The Navy continued development of the M&S suite to supplement live testing in order to assess the Probability of Raid Annihilation requirement for the self-defense mission for DDG 51 Flight III ships in FY23-24. As part of the overall M&S development strategy, the Navy plans to make limited use of the M&S suite for operational testing of the ACB-16 in FY23.
- Navy ACB-16 Phase 1 testing schedules shifted, with operational testing of ACB-16 Phase 1 capabilities now delayed until 2022.
- The updated Navy Aegis Modernization TEMP covering ACB-16 Phases 0, 1, and 2 testing is currently in the Navy staffing process for review and approval.
- ACB-16 9.A2A cybersecurity testing continues to be delayed into 2QFY21.

Assessment

- Operational testing of ACB-16 9.A2A on Navy cruisers indicates that air-defense performance was no better than the performance of previously evaluated Baseline 9 ships; surface warfare performance remains consistent with historical performance. The Navy 9.A2A cruisers were found to be less suitable than previously evaluated Baseline 9 ships. A more detailed assessment of air-defense, surface warfare, and suitability can be found in the March 2020 DOT&E Early Fielding Report.
- Results of previous Aegis Baseline 9.A (cruisers) cyber survivability testing are in the July 2015 DOT&E AWS Early Fielding Report. Assessment of the 9.A2A cybersecurity posture is incomplete pending completion of the cybersecurity operational test. DOT&E's cybersecurity assessment remains unchanged.
- Final assessment of software capabilities incorporated into ACB-16 to increase ships' air warfare performance against closely spaced threat raids is pending completion of additional phases of ACB-16 testing.
- The Aegis Modernization TEMP is currently out of date with respect to the Navy's Aegis fielding plans and test strategy.

Recommendations

The Navy should:

1. Complete update and staffing of the Aegis Modernization TEMP covering ACB-16 testing for final review and approval.
2. Complete the ACB-16 Phase 0 (9.A2A) cybersecurity testing, which is now scheduled to be conducted in 2QFY21.
3. Complete remaining planned ACB-16 testing.
4. Document test strategies and resources for future Aegis upgrades beyond ACB-16 to include Capability Package software updates.
5. Continue development efforts to provide an accredited M&S suite of the Aegis Combat System to adequately assess the Probability of Raid Annihilation requirement for the self-defense mission for Flight III DDG 51 destroyers and ACB-20.

AIM-9X Air-to-Air Missile Upgrade Block II

Executive Summary

- The Navy and the Air Force executed FOT&E of the AIM-9X Block II missile, with the Operational Flight Software (OFS) 9.410, from May 2020 until November 2020. FOT&E included six scored missile launches; captive-carry testing to examine acquisition, tracking, and reliability; and modeling and simulation (M&S).
- The Captive Carry Reliability Program (CCRP) provided the data needed to evaluate if the suitability deficiency of AIM-9X Block II employed by the F/A-18 aircraft, identified in IOT&E, has been sufficiently addressed. CCRP also provided the data to confirm that the suitability of the AIM-9X, employed by F-15 and F-16 aircraft, demonstrated in IOT&E, has been maintained.
- The Navy and the Air Force started a joint cybersecurity test for AIM-9X Block II and AIM-120C/, independent of FOT&E, although testing was postponed until December 2020 due to the delivery delays of the integration build weapon software.
- In FY20, the Program Office initiated the AIM-9X lethality evaluation against an updated target set which includes a range of fixed-wing aircraft, rotorcraft, unmanned aerial vehicles, and ground targets. The Program Office expects to complete the lethality assessment in 1QFY21.

System

- AIM-9X is the latest-generation, short-range, infrared-tracking, air-to-air missile. It is highly maneuverable and day/night capable.
- The AIM-9X threshold platforms are the F-15C/D and the F/A-18A+/C/D/E/F aircraft. Objective aircraft are the F-16C/D, EA-18G, F-15E, F-22A, and F-35A/B/C.
- The Assistant Secretary of the Navy (Research, Development, and Acquisition) approved full-rate production of the AIM-9X Block II missile via an Acquisition Decision Memorandum dated August 17, 2015.
- AIM-9X Block II missiles are currently fielded with OFS 9.317, which includes datalink, lofted trajectories, full cue lock-on-after-launch capability, and improved high-off boresight capability and flare rejection.
- OFS 9.410 is the latest update and consists of a software-only enhancement to provide improved Infrared Counter-Countermeasures, probability of kill enhancements, and partial/degraded cueing capabilities.
- Additional preplanned hardware improvements and obsolescence upgrades include the Inertial Measuring Unit, Missile Processor Unit, Control Actuation System battery, and a Nanocomposite Optical Ceramic missile seeker dome. Planned changes to the missile hardware will not add additional mission capabilities or affect system performance.
- OFS 9.410 and the hardware improvements/obsolescence upgrades are not coupled and will be implemented independently.

Mission

Joint Service (Navy/Marine Corps and Air Force) air combat units use the AIM-9X to:

- Conduct short-range air-to-air combat
- Engage multiple enemy aircraft types with passive infrared guidance in the missile seeker
- Seek and attack enemy aircraft at large angles away from the heading of the launch aircraft

Major Contractor

Raytheon Missiles & Defense – Tucson, Arizona

Activity

- The Navy and Air Force conducted the operational and cybersecurity testing, and lethality M&S in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and LFT&E Strategy.
- AIM-9X Block II FOT&E, executed from May 2020 until November 2020, included six operational flight tests of the AIM-9X Block II with OFS 9.410, captive carry testing, and M&S runs.
- In May 2020, the Accreditation Review Panel members signed the Raytheon M&S Acceptability Assessment Report.
- In FY20, the Navy and Air Force started the joint cybersecurity test for AIM-9X Block II and AIM-120C/D,

independent of the FOT&E, and will complete testing in December 2020 when Raytheon expects to deliver the integration build weapon software.
- In FY20, the Program Office initiated the M&S of AIM-9X against an updated target set which includes a range of fixed-wing aircraft, rotary-wing aircraft, unmanned aerial vehicles, and ground targets.

Assessment

- The AIM-9X Block II, with OFS 9.410, FOT&E is expected to complete in 1QFY21.
  - Initial indications suggest AIM-9X Block II 9.410 is effective. In flight tests, five of the six missile launches achieved a lethal intercept, and captive-carry testing demonstrated that the weapon is meeting the acquisition and tracking performance requirements.
  - Suitability data collected to date indicate that the AIM-9X Block II 9.410 will meet the suitability requirements, as employed by the F-15 and F-16 aircraft.
  - The collected suitability data will be used to evaluate if the suitability deficiency of AIM-9X Block II employed by the F/A-18 aircraft, identified in IOT&E, has been sufficiently addressed.
- Cybersecurity testing is focused on the weapon OFS, host platform 1553 bus connection, missile datalink, Munitions Application Program software, and Common Munitions BIT/Reprogramming Equipment support. Final analysis and a report will be delivered after the completion of the cybersecurity testing.
- AIM-9X lethality evaluation against eight air and ground targets is on track and scheduled to be completed in 1QFY21.

Recommendation

1. The Services should complete cybersecurity testing on the AIM-9X in accordance with the Cybersecurity Test Plan approved by DOT&E on September 9, 2019.

Amphibious Combat Vehicle (ACV) Family of Vehicles

Executive Summary

- From June to September 2020, the Marine Corps Operational Test and Evaluation Activity (MCOTEA) conducted the IOT&E for the Amphibious Combat Vehicle (ACV).
- During IOT&E, the ACV-equipped unit demonstrated the ability to maneuver, conduct immediate action drills, and provide suppressive fires in support of dismounted infantry in a desert environment. The ACV demonstrated water mobility and the ability to self-deploy from the beach, cross the surf zone, enter the ocean, and embark aboard amphibious shipping. The infantry rifle company equipped with the ACV was able to deploy from amphibious shipping, maneuver on the beach, and conduct subsequent offensive and defensive operations ashore.
- While the ACV demonstrated good operational availability and maintainability during IOT&E, it did not meet its 69-hour mean time between operational mission failures (MTBOMF) threshold. The program intends to conduct follow-on reliability testing and implement fixes into future vehicles to improve reliability.
- BAE Systems remains on track to meet vehicle delivery requirements. Temporary closures and reduced staffing at the York, Pennsylvania, facility due to the coronavirus (COVID-19) pandemic resulted in vehicle delivery delays during 3QFY20.
- In December 2018, the Marine Corps started the ACV full-up system-level (FUSL) live fire test series at the Army's Aberdeen Test Center, Maryland. The test series included 26 events using 4 low-rate initial production (LRIP) and 3 engineering and manufacturing development (EMD) ACVs to support the evaluation of the survivability of the ACV and its crew in projected combat scenarios. In August 2020, the Aberdeen Test Center completed all test events in accordance with DOT&E-approved test plans.

System

- The Marine Corps intends to field a vehicle capable of providing expeditionary protected mobility and general support lift to the Marine Infantry Battalion as part of a Ground Combat Element-based maneuver task force. The ACV is a family of vehicles that includes a personnel, command and control, recovery, and 30-mm gun variants. The ACV Program Office is focusing current procurement efforts on the personnel variant.
- The ACV is a modern generation, eight-wheeled, armored personnel carrier with a combat-loaded gross vehicle weight of 70,000 pounds. The primary weapon on the ACV is a single mount Remote Weapons System (RWS) equipped with an MK 19 automatic grenade launcher or M2 .50 caliber heavy machine gun.

- The Marine Corps intends the ACV to operate with Marine Air Ground Task Force maneuver formations, and achieve up to 6 knots while operating at sea. The ACV will carry a crew of 3 operators and 13 embarked infantry Marines with 2 days of supplies and combat essential equipment.
- The Marines desire the ACV to provide effective land and tactical water mobility (ship-to-shore and shore-to-shore), precise supporting fires, and high levels of force protection. The Marines intend to provide survivability against blasts, fragmentation, and kinetic-energy threats while supporting combat-loaded marines as they close with and destroy the enemy, respond to crises, and conduct stability operations.
- The planned acquisition objective of 632 ACVs will replace the legacy Amphibious Assault Vehicles (AAVs) fielded to the Assault Amphibian battalion within the Marine Division. The previous acquisition objective of 1,122 has been reduced in accordance with Marine Corps Force Design 2030 modernization efforts.

Mission

- Commanders will employ ACV-equipped units to land the surface assault elements of the landing force in order to seize inland objectives and conduct mechanized operations in support of subsequent actions ashore.
- Assault Amphibian Battalions equipped with the ACV will provide task-organized units to transport personnel, equipment, and supplies ashore from amphibious shipping;

execute ship to-shore and riverine operations; support breaching of barriers and obstacles; and provide embarked infantry with armor-protected firepower, extended communications capabilities, and mobility on land and sea.

- ACV-equipped units will provide protected mobility to embarked infantry and deliver precision support-by-fire effects in support of dismounted infantry maneuver. ACV-equipped units will conduct mounted security operations in urban or restrictive terrain alongside other vehicles within the Marine Air Ground Task Force or Marine Division.

Major Contractor

BAE Systems – York, Pennsylvania

Activity

- In June 2018, the Marine Corps awarded the ACV Family of Vehicles LRIP contract to BAE Systems. The performance of the ACV1.1 program during it developmental testing and operational assessment led to the consolidation of the ACV 1.1 and ACV 1.2 programs in January 2019.
- The Program Manager, Advanced Amphibious Assault (PMAAA) conducted, and MCOTEA observed, an ACV Logistics Demonstration (LOGDEMO) in December 2019 to validate and correct technical manuals, repair procedures, and tooling in accordance with operator and maintenance tasks.
- DOT&E approved the ACV IOT&E plan in June 2020.
- From June 1 to September 5, 2020, MCOTEA conducted IOT&E at Camp Pendleton, California, and the Marine Corps Air Ground Combat Center, Twenty-Nine Palms, California, in accordance with the DOT&E-approved test plan. The test consisted of a Marine Rifle Company (approximately 200 marines) embarked on a platoon of 18 ACVs conducting operationally representative missions based on the ACV Operational Mode Summary/Mission Profile.
- MCOTEA conducted a cooperative vulnerability and penetration assessment (CVPA) followed by an adversarial assessment (AA). Both the CVPA and AA were rescheduled during IOT&E due to the COVID-19 pandemic, and conducted in accordance with the DOT&E-approved test plan.
- In December 2018, the Marine Corps began the execution of the ACV FUSL live fire test series at the Army Aberdeen Test Center, Maryland. The test series included 26 events using 4 LRIP and 3 EMD ACVs to support the evaluation of the survivability of the ACV and its crew in projected combat scenarios. In August 2020, the Aberdeen Test Center completed all test events in accordance with DOT&E-approved test plans.
- DOT&E approved the Event Design Plan for the ACV command and control variant in August 2020. LFT&E activity for the command variant is scheduled to begin 2QFY21.
- DOT&E published an IOT&E and LFT&E report in November 2020 in support of the Full-Rate Production decision.

Assessment

- The IOT&E was adequate to support an evaluation of the ACV.
- The Marine Infantry Company and attached Assault Amphibian platoon equipped with the ACV was successful in 12 of 13 missions and demonstrated the capability to operate across both desert and littoral environments. Vehicle crewmen operated the ACV alongside Joint Lightweight Tactical Vehicles (JLTVs), Light Armored Vehicles (LAVs), and other tactical vehicles to maneuver and achieve tactical advantage over the opposing force. Marines involved with the test noted that the ACV performed better than the legacy vehicle across all mission profiles. The ACV modern interface, including cameras, intercom, and RWS improved the unit's situational awareness and ability to locate and suppress the enemy.
- On land, the ACV platoon was able to maneuver into tactical formations, observe adjacent vehicles and interoperate with other tactical vehicles (LAV, Logistics Vehicle Replacement (LVSR), and JLTV. The ACV demonstrated the capability to negotiate terrain in the desert and littoral areas, and maneuver to achieve tactical advantage over the opposing force.
- During amphibious operations, the ACV platoon was able to self-deploy from the beach, cross the surf zone to enter the ocean, and return through the surf zone to the beach. With a Marine Infantry company embarked on the ACVs, the ACV platoon was able to launch and recover from an amphibious ship, conduct a 12-nautical mile open ocean swim, cross the surf zone, and continue to inland objectives.
- The ACV RWS equipped with the M2 .50 caliber heavy machine gun provided the dismounted infantry company with accurate, sustained, direct fire support across all land mission profiles. The RWS offers several advantages over the legacy AAV Up-gunned Weapons Station, to include a dedicated gunner, weapons and sight stabilization, a laser range finder, and a modern fire control system. During gunnery live-fire against stationary targets, ACV sections hit 91 percent of targets when the ACV was stationary, and 97 percent of targets while the ACV was on the move.
- ACV land mobility in the desert environment was often degraded by tire failures, which led to 2-hour mission delays while crews replaced or swapped tires. The ACV platoon did not have a hydraulic jack or other means to lift the ACV without an LVSR Wrecker. Some tire failures could be attributed to incorrect tire pressure settings in the Central Tire Inflation System (CTIS) on the ACV. As crews actively monitored CTIS settings, tire failures were less frequent.
- The weight, height, and size of the ACV made recovery of a disabled ACV challenging and time consuming, at times requiring additional LVSR support. When vehicles sustained

severe damage to suspension components or became mired, one or more LVSRs were required to recover the ACV. LVSRs are on the Table of Organization for the Assault Amphibian Battalion, and Marine Corps Maintenance Battalions. Additional LVSRs may be required to support future ACV platoon or company-level operations.

- The ACV threshold requirement for quantity of personnel carried is 3 crewmen and 13 embarked infantry with full combat loads, including 2 days of supply and combat essential equipment. The ACV accommodated 3 crew and 13 embarked infantry. Due to the placement and number of blast mitigating seats, interior space within the ACV is limited, making rapid ingress and egress difficult.
- Infantry troop commanders were able to task organize marines and equipment within the ACV to meet specific mission requirements (i.e., mortar teams, machine gunners, anti-tank missile operators, and unmanned aerial system teams). Infantry leaders were able to manage available seats to preserve combat power if an ACV was not able to continue the mission.
- Infantry Marines noted that the troop seats were not contoured to fit body armor configurations, leading to discomfort during long range ship-to-objective missions.
- Effective unit maintenance training prior to IOT&E during the New Equipment Training phase led to high operational availability during IOT&E.
- The ACV demonstrated an MTBOMF of 39.0, which is less than the 69-hour MTBOMF reliability requirement. The RWS, which is government-furnished equipment, was the source of the largest number of operational mission failures (OMFs). Other subsystems with a high failure rate included suspension components, hatch and ramp sensors, and switches. The ACV program plans to continue reliability improvement efforts beyond full-rate production.
- The CVPA focused on components in the vehicle that interacted with the Controller Area Network bus. Test results were consistent with 2018 findings within the 2018 DOT&E Operational Assessment report, and confirmed that electronic segmentation of communications and automotive subsystems minimized the attack surface. Testing during the AA focused on scenarios designed to assess time to detect, time to recover, and mission effects of cyber compromise. ACV operators demonstrated the ability to defend and recover against some insider and nearsider cyberattacks.
- The survivability evaluation of the baseline ACV is detailed in the classified annex of the November 2020 DOT&E report. It documents vulnerabilities demonstrated during LFT&E and provides detailed recommendations to improve survivability and force protection against kinetic threat engagements.

Recommendations

The following is a summary of key recommendations for the ACV. A complete list of recommendations is contained in the November 2020 DOT&E report. The Marine Corps and the Program Manager, Advanced Amphibious Asault should:

1. Mitigate the vulnerabilities documented in the classified annex of the DOT&E IOT&E and LFT&E report in order to improve ACV survivability and force protection against kinetic threats.
2. Continue to improve ACV reliability by implementing corrective actions on future LRIP vehicles to reduce failure rate and maintenance demand.
3. Develop and provide equipment that allows more efficient tire changes in an expeditionary environment, and consider adding a spare tire kit at the section level.
4. Consider the modification of troop seat pad to accommodate infantry body armor.

AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat Systems Suite

Executive Summary

- The Navy's Operational Test and Evaluation Force (OPTEVFOR) commenced FOT&E on the AN/SQQ-89A(V)15 Advanced Capability Build (ACB)-13 variant with the exception of the Continuous Active Sonar operational testing, which was canceled due to asset unavailability.
- OPTEVFOR completed combined operational cybersecurity testing on AN/SQQ-89A(V)15 ACB-11 and ACB-13. In 2QFY20, DOT&E submitted a classified cybersecurity update to its previous IOT&E report.
- DOT&E approved the Test and Evaluation Master Plan (TEMP) for the ACB-15 variant in October 2020.

System

- The AN/SQQ-89A(V)15 is an integrated undersea warfare (USW) combat system that is deployed on *Ticonderoga*-class cruisers and *Arleigh Burke*-class destroyers. It is composed of the sensors, processors, displays, and weapon controls to detect, classify, localize, and engage threat submarines and alert on threat torpedoes. It is an open-architecture system that includes staggered biennial software upgrades (ACBs) and biennial hardware upgrades (Technical Insertions).
  - Acoustic sensors include a hull-mounted array, Multi-Function Towed Array (MFTA) TB-37 (including a towed acoustic intercept component), Noise Monitoring Hydrophones, helicopter, and/or ship-deployed sonobuoys.
  - Functional segments process and display active, passive, and environmental data.
- The AN/SQQ-89A(V)15 interfaces with the Aegis Combat System to prosecute threat submarines using MK 54 torpedoes from surface vessel torpedo tubes, Vertical Launch Anti-Submarine Rockets, or MH-60R helicopters.

Mission

- Theater and Unit Commanders use surface combatants equipped with the AN/SQQ-89A(V)15 to locate, monitor, and engage threat submarines.
- Maritime Component Commanders employ surface combatants equipped with the AN/SQQ-89A(V)15 as escorts to high-value units to protect against threat submarines during transit. Commanders also use the system to conduct area clearance and defense, barrier operations, and anti-submarine warfare (ASW) support during amphibious assault.

Major Contractor

Lockheed Martin Mission Systems and Training – Manassas, Virginia

Activity

- In March 2020, DOT&E submitted a classified Cybersecurity Update Report to the December 2018 ACB-11 IOT&E report. That report details the cyber survivability of ACB-11 as well as the subsequent variant, ACB-13.
- In October 2020, DOT&E approved the AN/SQQ-89A(V)15 TEMP 802-2, Revision 8. Revision 8 includes an Annex that describes the testing strategy for ACB-15.
- In 4QFY20, asset unavailability resulted in a cancelation of ACB-13's Continuous Active Sonar operational test.

Assessment

- The final assessment of AN/SQQ-89A(V)15 ACB-13 is not complete, as testing is expected to continue into FY21. DOT&E's assessment of this system remains largely unchanged from the IOT&E report for ACB-11.
- Cybersecurity results affecting ACB-11 and ACB-13's operational effectiveness are included in the classified March 2020 update.
- ACB-11 is untested against operationally relevant midget and coastal diesel submarine threats. The Navy has no

representative surrogate for this type of submarine to use for test.

- Operational availability of MFTA is low, primarily due to extensive logistical delays associated with its repair. ACB-11 uses MFTA as a primary sensor for submarine search and torpedo defense. MFTA operational availability has demonstrated some improvement, likely due to Navy action to increase MFTA spare parts inventory.

Recommendations

The Navy should:

1. Address the recommendations in the classified DOT&E IOT&E cybersecurity update for ACB-11 and ACB-13.
2. Develop a representative surrogate for testing AN/SQQ-89(V)15 performance against midget and coastal diesel submarine threats.
3. Continue efforts to improve the operational availability of MFTAs.

CH-53K – Heavy Lift Replacement Program

Executive Summary

- The Navy is testing in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and a DOT&E-approved 2010 Alternative Live Fire Test and Evaluation (LFT&E) plan. The program has seven flyable aircraft to support integrated developmental and operational flight testing. The contractor has delivered three of the four System Development Test Articles (SDTA), all of which are participating in the test program. The seven flyable aircraft have flown 2,138.1 flight hours as of September 30, 2020.
- The Navy is implementing corrections to multiple design deficiencies discovered during developmental testing. These include: hot gas ingestion by the number 2 engine; low reliability of main rotor gearbox; hot gas impingement on aircraft structures; tail boom and tail rotor structural problems; overheating of main rotor dampers; high temperatures in the number 2 engine bay; and wheel brakes.
- The Program Office is preparing a Memorandum of Understanding for endorsement by Commander, Operational Test and Evaluation Force, Marine Corps Deputy Commandant for Aviation, and DOT&E that describes a three-period IOT&E test schedule. DOT&E is collaborating with the Navy and other stakeholders to determine the specific IOT&E entry criteria as part of the Operational Test Readiness Review process.
- In May 2020, the Navy restarted the LFT&E program after an 18-month delay caused by funding constraints. The Navy is currently executing live fire testing on the Ground Test Vehicle at China Lake, California, which is expected to be complete in July 2021. In conjunction with tail rotor flexbeam and installed armor testing, this will complete Phase I of the LFT&E testing.
- The Navy has neither funded nor adequately scoped Phase II of the LFT&E activities as required by the DOT&E-approved LFT&E plan and as necessary to fully assess the vulnerability of the aircraft against operationally realistic kinetic threats.

System

- The CH-53K is a new-build, fly-by-wire, dual-piloted, three-engine, heavy-lift helicopter slated to replace the aging CH-53E. The CH-53K is designed to carry 27,000 pounds of useful payload (three times the CH-53E payload) over a distance of up to 110 nautical miles, climbing from sea level at 103 degrees Fahrenheit to 3,000 feet above mean sea level at 91.5 degrees Fahrenheit.
- The CH-53K design incorporates the following survivability enhancements:

  - Large Aircraft Infrared Countermeasures with advanced threat warning sensors (combines infrared, laser, and hostile fire functions into a single system), an AN/APR 39C(V)2 radar warning receiver, and an AN/ALE-47 countermeasure dispensing system
  - Pilot armored seats, cabin armor for the floor and sidewalls, fuel tank inerting, self-sealing fuel bladders, and 30-minute run-dry capable gear boxes.
- The Navy intends the CH-53K to maintain a shipboard logistics footprint equivalent to that of the CH-53E.

Mission

Commanders employ the Marine Air-Ground Task Force equipped with the CH-53K for:

- Heavy-lift missions, including assault transport of weapons, equipment, supplies, and troops
- Supporting forward arming and refueling points and rapid ground refueling
- Assault support in evacuation and maritime special operations
- Casualty evacuation
- Recovery of downed aircraft, equipment, and personnel
- Airborne control for assault support

Major Contractor

Sikorsky Aircraft (a Lockheed Martin subsidiary company) – Stratford, Connecticut

Activity

- The Navy is testing in accordance with the DOT&E-approved TEMP and a DOT&E-approved 2010 Alternative LFT&E plan. The program has seven flyable aircraft to support integrated developmental and operational flight testing. The contractor has delivered three of the four SDTA, all of which are participating in the test program. The seven flyable aircraft have flown 2,138.1 flight hours as of September 30, 2020. SDTA-4, the last of the four aircraft for IOT&E, is scheduled to arrive at Marine Corps Air Station New River, North Carolina, in March 2021.
- The Program Office recovered the contractor test personnel shortfalls from FY19 and returned to full staffing by January 2020.
- The Navy has initiated several design changes to fix deficiencies discovered during testing:

  Engine Integration
  - The Navy identified engine exhaust gas re-ingestion (EGR) as a significant technical deficiency to be solved prior to IOT&E. In addition to EGR, the program addressed exhaust gas impingement on the skin of the aircraft. A third challenge related to EGR is engine bay overheating, which required improved airflow to cool without adversely affecting the ability to extinguish potential engine fires.
  - The program selected several prototypes for fabrication and installation on flight test aircraft. Aircraft modifications began in October 2019, and initial developmental flight test events began in December 2019. The prototype designs will be installed on the IOT&E aircraft.

  Main Gearbox (MGB)
  - The program improved the design of the Main Gearbox (MGB) after qualification tests found the first Engineering Development Model MGB designs to be much less durable than required. The Integrated Test Team (ITT) installed the improved design MGB on one aircraft, and resumed flight testing in May 2019.

  Tail Rotor Flexbeam
  - Early tail rotor flexbeam composite material designs delaminated during flight test efforts. Sikorsky improved the flexbeam manufacturing process. The ITT installed the new flexbeam in May 2019 and returned to flight test.

  Main Rotor Damper
  - The dampers, which are designed to reduce vibration loads in the main rotor system, experienced load spikes due to several design characteristics. Sikorsky has redesigned the dampers, and additional design changes have been made after the ITT installed and tested the new dampers during FY20. Preliminary test results from hot environment testing are positive.

  Intermediate Ground Mode during Aircraft Launch
  - A failure condition occurred during flight test events when the aircraft transitioned from ground to flight. This condition could result in the pilots losing control of the aircraft. The program completed several design changes in the flight control software and added an override switch to allow the pilots to select the flight control laws manually prior to takeoff. The ITT began flight test events in February 2020.

  Wheel Brakes
  - The original wheel brake design used a two-stage master brake cylinder and close tolerance brake caliper to meet all requirements. This resulted in brake heating during taxi, excessive pedal travel, and unpredictable response when transitioning between stages. Sikorsky used modeling and simulation (M&S) as well as a full-scale component test at the brake supplier to determine that an accumulator system must be added to the system. Initial ground taxi tests resumed in September 2020.

- The ITT conducted developmental flight testing at sea aboard an Amphibious Assault Ship in June 2020. The test team conducted tests to verify the launch and recovery wind envelopes that were predicted by M&S. The test team conducted tests to determine wind conditions that have the potential to damage the aircraft during spreading and folding of the rotor blades. The test team collected data for Intermediate Ground mode software testing during the shipboard testing.
- The ITT completed developmental flight testing in Yuma, Arizona, as part of Degraded Visual Environment (DVE) and high ambient temperature testing. Testing was performed in full brownout conditions and with temperatures in excess of 115 degrees Fahrenheit. The Developmental Test report published on September 10, 2020, indicates engine performance degrades below acceptable minimums after 21 minutes of exposure to brownout conditions. The aircraft's operating manual limits permissible engine exposure to brownout during a maneuver to 70 seconds.
- The Program Office is preparing a Memorandum of Understanding for endorsement by Commander, Operational Test and Evaluation Force, Deputy Commandant for Aviation, and DOT&E that describes a three-period IOT&E test schedule. DOT&E is collaborating with the Navy and other stakeholders to determine the specific IOT&E entry criteria as part of the Operational Test and Evaluation Readiness Review process.
- The program has made a design change to the Aircraft Survivability Equipment (ASE) that relocates the Guardian Laser Turret Assemblies (GLTA) infrared jammers due to interference from the aircraft engine exhaust plume that could adversely affect the aircraft survivability equipment performance. The design change will not be available for the start of IOT&E Period 1. The ITT will test the new design on an EDM during IOT&E Period 2 at Naval Air Station (NAS) Patuxent River, Maryland, with support from VMX-1. VMX-1 will test the new design as installed on a production line aircraft during IOT&E Period 3 at Marine Corps Air Station (MCAS) New River, North Carolina.
- The ITT discovered Sikorsky Configuration Management (CM) errors that hampered flight test execution. Inaccurate CM logs for aircraft life-limited components led the HX-21

Commanding Officer to halt operations while the logs were audited. This caused a loss of approximately 3 weeks of flight test productivity.
- In 3QFY20, the Navy resumed live-fire testing of CH-53K on the Ground Test Vehicle (GTV) starting with fuel cell and sponson testing against threshold threats under cruise and hover conditions. GTV live-fire testing of fuel, hydraulics, drive, propulsion, flight controls, structure, and tail rotor systems will take place in two additional test periods in 1QFY21 and 4QFY21.
- Tail rotor blade ballistic testing, including testing of the redesigned tail rotor flexbeam and dynamic testing of post-ballistic articles under 30-minute fly-home loads, is scheduled to begin in November 2020.
- Manufacturer qualification ballistic testing of the cabin armor was completed in 4QFY20. Live-fire testing to evaluate the effectiveness of the armor against operationally representative kinetic threats is scheduled to occur in 1QFY21.
- The Program Office has continued to defer Phase II of the LFT&E program until after IOC. This testing, defined in the DOT&E-approved Alternate LFT&E Strategy, has not yet been fully funded.

Assessment
- Rebaselined projections estimate that IOT&E will begin in 3QFY21 due to technical problems that have extended System Design and Development beyond original projections.
- EGR testing led to additional, small changes to the prototype design solution. Once those changes were made, flight testing showed the design solution virtually eliminated exhaust reingestion by the engines. Sikorsky will incorporate the design changes into the production aircraft.
- CH-53K's advanced flight control software provides more control stability than older variants of the aircraft. Test data from the shipboard testing should result in a larger wind envelope for CH-53K.
- Transmission Time-Between-Overhaul will increase as the ITT conducts test events with the new MGB design installed and subsequent maintenance inspections are completed.
- Wheel Brakes have been a known issue for well over 2 years, and Sikorsky will have an interim design for IOT&E. DOT&E fully expects the operational testers will write one or more major deficiencies against the IOT&E brake design. Sikorsky has begun to work on a permanent, productionized brake.
- Engine performance degradation in brownout conditions will necessitate extremely frequent engine replacements and repair if the Marine Corps continues to train and operate in locations where brownout conditions are prevalent. CH-53K aircrew cannot realistically perform external cargo delivery operations within the 70-second operating limit.
- IOT&E aircraft are required to be production representative. The three-period IOT&E schedule described in the MOU will include testing on a low-rate initial production aircraft in Period 3.
- Sikorsky's CM systems are not fully integrated across the entire Sikorsky production and flight test databases. Configuration changes that are entered into one database do not promulgate throughout the rest of the configuration accounting databases. This results in inconsistent, inaccurate databases and aircraft log books, and has the potential for aircraft components to remain installed beyond their recommended life limits. Sikorsky has added manpower and funding to update their systems to better integrate the promulgation of updates across the CM enterprise.
- The ITT depends on consistent flight test execution to maintain progress toward IOT&E and allow newer flight test pilots and engineers to gain the experience necessary to conduct more complex flight test events.
- Phase II of the LFT&E program is essential for a complete survivability assessment of CH-53K against operationally relevant threats. This phase includes component tests for the main rotor assembly and tail rotor hub against threshold threats originally scheduled to support the Milestone C decision. Any deficiencies identified in this phase of testing will need to be resolved after Initial Operational Capability.

Recommendations
The Navy should:
1. Ensure Sikorsky adequately invests in the completion of CM enterprise improvements. Those improvements will have larger benefits in future programs, such as Future Vertical Lift.
2. Develop a sustainable FOT&E test program to evaluate deployment capabilities that will not be tested in IOT&E. The FOT&E test program should verify that any changes to the aircraft to correct deficiencies are effective and suitable.
3. Develop and fully fund Phase II of the LFT&E program as described in the DOT&E-approved LFT&E Strategy.
4. Continue to develop mitigations to address design deficiencies identified in test.

CMV-22B Joint Services Advanced Vertical Lift Aircraft – Osprey – Carrier Onboard Delivery

Executive Summary

- The Navy is testing in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP) and Alternative LFT&E plan dated March 20, 2020.
- Changes to the baseline MV-22B design include increased fuel capacity, incorporation of CV-22B fuel jettison, integrated public address (PA) system, high-frequency (HF) radio, cabin and cargo lighting, and a Navy paint scheme.
- Fleet Logistics Squadron VRM 30/40 detachments equipped with CMV-22B will perform the primary mission of Airborne Resupply/Logistics for Seabasing (AR/LSB).
- Operational Test and Evaluation Squadron VX-1, supported by aircraft and personnel from VRM-30, will conduct Operational Test period OT-D1, which is scheduled to begin in January 2021.
- In order to evaluate the effects of the CMV-22B survivability and force protection against operationally relevant kinetic threats, the LFT&E Strategy heavily leveraged previous MV-22B data. LFT&E testing is focused on the evaluation of the effects of changes to the fuel system design on survivability.

System

- The CMV-22B Osprey is a tiltrotor Vertical/Short Takeoff and Landing (V/STOL) aircraft. The design of the CMV-22B is based on the MV-22B.
- Changes to the baseline MV-22B design include increased fuel capacity, incorporation of CV-22B fuel jettison, integrated PA system, HF radio, cabin and cargo lighting, and a Navy paint scheme.
- Increased fuel capacity design changes include an enlarged aft sponson and new wing fuel tanks.
- The fuel jettison system will exit at the left-hand lower tail section and will ensure no fuel impingement while in airplane mode.
- The PA system will provide a handheld microphone to make audio broadcasts in the aircraft cabin.
- The HF Radio will utilize the same antenna and antenna tuning unit as the CV-22B.
- The aft cabin and cargo lighting solution will be compatible with Night Vision Imaging System (NVIS) white lighting and green lighting configurations and will include a cabin control panel.

Mission

- Fleet Logistics Squadron VRM 30/40 detachments equipped with CMV-22B will perform the primary mission of Airborne Resupply/Logistics for Seabasing (AR/LSB).
- The CMV-22B fills the Joint Force Maritime Component Commander time-critical logistics air connector requirements by transporting personnel, mail, and priority cargo from advance bases to the Seabase.
- Additional secondary missions include: Vertical Onboard Delivery; Vertical Replenishment (VERTREP); Medical Evacuation (MEDEVAC); Naval Special Warfare (NSW) Support; Missions of State; and Search and Rescue (SAR) Support.

Major Contractors

Bell-Boeing Joint Venture:

- Bell Helicopter – Amarillo, Texas
- The Boeing Company – Ridley Township, Pennsylvania

Activity

- The Navy has been conducting integrated developmental and operational, cybersecurity, and live fire testing in accordance with the DOT&E-approved TEMP and Alternative LFT&E Strategy dated March 20, 2020.
- CMV-22B developmental test aircraft N-1 is part of the V-22 Multi-Year 3 production contract, and has been augmented with temporary instrumentation to support developmental test. N-1 supported Bell-Boeing acceptance and developmental tests to validate the initial flight clearance from December 2019 to January 2020. N-1 ferried to Developmental Test and Evaluation Squadron HX-21 at

the Naval Air Station (NAS) Patuxent River, Maryland, on February 2, 2020.
- CMV-22B developmental test aircraft N-2 is part of the V-22 Multi-Year 3 production contract. It has permanent instrumentation installed to support flight envelope developmental test. N-2 ferried to HX-21 at NAS Patuxent River, Maryland, on May 21, 2020.
- As of September 30, 2020, Bell-Boeing has delivered 4 of 44 planned fleet aircraft to Fleet Logistics Squadron VRM-30 at NAS North Island, California.
- HX-21 implemented two shift maintenance teams in the spring of 2020 to mitigate the coronavirus (COVID-19) pandemic exposure risks. The Program Office prioritized test efforts for other aircraft supporting test events, which slowed progress on N-2's acceptance at the squadron. The test team conducted CMV-22B test flights while supporting two high priority MV-22B shipboard test periods. Both test periods required 40 members of the test team to conduct a 2-week Restriction of Movement (ROM) period due to COVID-19 protocols, which reduced manpower availability and affected flight test productivity. The test program is approximately 6 weeks behind schedule, but has improved test productivity since the shipboard test periods. The Integrated Test Team (ITT) projects it will be on schedule by November 2020.
- N-1 and N-2 have flown 111.8 hours as of September 30, 2020. CMV-22B ITT has conducted test events to collect data on the fuel system, aircraft flying qualities and structural loads, and to measure the effects of operating in an electromagnetic environment
- VX-1, supported by aircraft and personnel from VRM-30, will conduct OT-D1, which is scheduled to begin in January 2021. OT-D1 will include test periods at sea aboard an aircraft carrier and at ashore fleet logistics locations during a carrier strike group Composite Training Unit Exercise (COMPTUEX).
- Bell-Boeing has begun a redesign effort for CMV-22B fuel bladders 4 and 5, the bladders located in the wings closest to the aircraft fuselage. The original design used 4-ply materials that were found to be difficult to manufacture, install, and service. The new design will use 2-ply materials, but the new design will not be installed in the OT-D1 aircraft. The time to develop and qualify the new design will delay live-fire testing of the wing tanks until 3QFY21.
- The Program Office is adding a commercial off-the-shelf (COTS) interim solution for Required Navigation Performance/Area Navigation (RNP/RNAV) to support CMV-22B's first deployment. RNP/RNAV provides onboard navigation performance monitoring and alerting capability to ensure that the aircraft stays within a specific containment area, and is a requirement for aircraft operations in certain areas around the world. The Program Office will implement a final, integrated RNP/RNAV system in 2QFY24.
- The ITT conducted a Cyber Table Top (CTT) exercise on January 14, 2020. Cyber test planning is in work. Developmental cyber testing is planned to begin in October 2020. A cooperative vulnerability and penetration assessment (CVPA) is planned for January 11 – 15, 2021, and the adversarial assessment (AA) is planned for January 18 – 22, 2021. The CVPA and AA test plans will incorporate the results from the CTT into the test design.
- In June 2019, the contractor performed Phase II qualification testing of the enlarged forward fuel sponson at China Lake, California. LFT&E of the 4-ply Wing Auxiliary Tanks No. 4 and No. 5 is planned for October 2020. LFT&E of the 2-ply Wing Auxiliary Tanks is planned for April 2021.

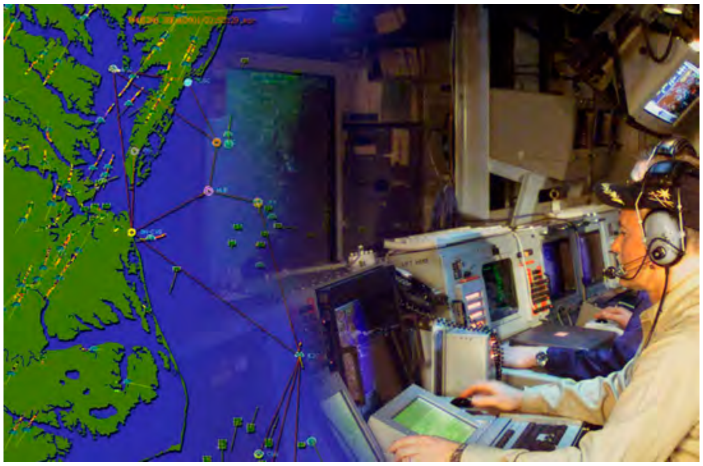
Assessment
- Developmental test events found the flying characteristics of the CMV-22B are very similar to the Marine MV-22B.
- Operational Test Squadron VX-1 has participated in Integrated Test (IT) efforts at HX-21. HX-21 and VX-1 have completed IT events for the PA system and cabin lighting system. Several deficiencies have been discovered, including PA system feedback and lighting panel control switch designs, which may result in additional changes to the PA and lighting systems.
- The CMV-22B will have maneuvering restrictions in effect until the ITT completes developmental flight envelope testing. The full maneuvering envelope will not be available for first deployment in 4QFY21. VX-1 will assess the maneuvering restrictions as part of OT-D1.
- Without RNP/RNAV, there will be arrival and departure limitations under instrument meteorological conditions at certain airfields and routing challenges due to elimination of ground-based navigation aids and V-22 navigation database limitations. These limitations will increase transit times due to suboptimal routing and prohibit entry into some airfields. The intent of the interim COTS GPS solution is to bridge the navigation capability gap between initially fielded aircraft and the Boeing/Raytheon integrated solution on the CMV-22B aircraft.
- Conducting OT-D1 during COMPTUEX with a full carrier air wing embarked aboard the aircraft carrier is operationally representative of how CMV-22B will integrate into the carrier strike group.
- Comparison of the qualification test data of the enlarged fuel sponson with legacy MV-22 data indicated that the vulnerability of this component is equivalent to that of the MV-22.
- Redesign of the wing fuel cells will delay the final survivability assessment to after Initial Operational Capability (IOC). The first 16 aircraft will be deployed with the original fuel cell design. The final survivability assessment will encompass both designs.

Recommendation
1. The Navy should ensure adequate resources for follow-on testing for the Boeing/Raytheon RNP/RNAV, and any other future capability improvements after IOC.

Cooperative Engagement Capability (CEC)

Executive Summary

- The Navy's Operational Test and Evaluation Force (OPTEVFOR) executed FOT&E of the USG-3B Cooperative Engagement Capability (CEC) in 2019.
- The USG-3B CEC FOT&E was inadequate because it was not conducted in accordance with the DOT&E-approved test plan.
- Though testing was not adequate to draw conclusions regarding effectiveness and suitability, results indicate that some deficiencies identified in earlier operational testing may have been corrected.
- While testing time was limited, results indicate that the USG-3B CEC is available and maintainable, but not reliable.



System

- CEC is a real-time sensor-netting system that enables high-quality situational awareness and integrated fire control capability.
- There are four major U.S. Navy variants of CEC:
  - The AN/USG-2/2A is installed on select Aegis cruisers and destroyers, *San Antonio* (LPD 17)-class and LHD amphibious ships, and *Nimitz* (CVN 68)-class aircraft carriers. The Navy is currently retiring the AN/USG-2/2A and replacing them with the AN/USG-2B CEC.
  - The AN/USG-2B, an improved version of the AN/USG-2/2A, is installed or planned to be installed on CVN 68 and *Gerald R. Ford* (CVN 78)-class aircraft carriers, *Zumwalt* (DDG 1000)-class destroyers, selected Aegis cruisers/destroyers, and selected amphibious assault ships.
  - The AN/USG-3 is installed on the E-2C Hawkeye 2000 aircraft. The AN/USG-3 is being retired as the aircraft are retired.
  - The AN/USG-3B is installed on the E-2D Advanced Hawkeye aircraft.
- The two major hardware components are the Cooperative Engagement Processor, which collects and fuses sensor data; and the Data Distribution System, which exchanges data between participating CEC units.
- CEC increases Naval Air Defense capabilities by integrating sensors and weapon assets into a single, real-time network that:
  - Expands the battlespace
  - Enhances situational awareness
  - Increases depth-of-fire
  - Enables longer intercept ranges
  - Improves decision and reaction times

Mission

Naval Commanders employ platforms equipped with CEC to:

- Improve battle force air and missile defense capabilities by combining data from multiple battle force air search sensors on CEC-equipped units into a single, real-time, composite track picture.
- Provide accurate air and surface threat tracking data to ships equipped with the Ship Self-Defense System.

Major Contractor

Raytheon Technologies Missiles and Defense –
St. Petersburg, Florida

Activity

- OPTEVFOR executed FOT&E of the USG-3B CEC in June 2019. Four events in the DOT&E-approved test plan were not completed. Multiple deviations from the test plan occurred within the completed events, including:
  - Failure to collect CEC data on board the aircraft for two events
  - Incorrect target flight altitudes
  - Incorrect Identification Friend or Foe Mode usage
- These deviations preclude DOT&E from determining the effectiveness or suitability of the CEC USG-3B.
- The Navy did not execute cybersecurity testing during this phase of FOT&E because the Program Office did not fund it.
- DOT&E issued a classified report on the USG-3B CEC FOT&E in November 2020.

- The Navy is updating the extant CEC Test and Evaluation Master Plan (TEMP) to address FOT&E of the USG-2B on board Aegis, DDG 1000, and CVN 78 class ships.
- The Navy is developing a new TEMP for CEC Block II, which will introduce new capabilities and more ambitious requirements for capabilities it shares with the current CEC build.

Assessment

- The USG-3B CEC FOT&E was inadequate to draw conclusions regarding effectiveness and suitability, but results indicate that some deficiencies identified in earlier operational testing may have been corrected.
- While testing time was limited, results indicate that the USG-3B CEC is available and maintainable, but not reliable. Additional data are required to determine the overall suitability of the USG-3B CEC.
- The Navy has not demonstrated the ability of the USG-3B CEC to support the E-2D’s Theater Air and Missile Defense mission and Battle Management Command and Control mission.

Recommendations

The Navy should:

1. Conduct cyber survivability testing on the USG-3B CEC as installed on the E2-D aircraft.
2. Collect additional USG-3B CEC data sufficient to conclusively assess the system’s suitability.
3. Take action on the recommendations contained in DOT&E’s classified FY21 report to Congress on the CEC USG-3B FOT&E.
4. Submit to DOT&E for approval the updated CEC TEMP that encompasses:
   - FOT&E of the USG-2B CEC with the Aegis, DDG 1000, and CVN 78 combat systems
   - FOT&E of the USG-3B CEC to demonstrate the system’s ability to support the E-2D’s Theater Air and Missile Defense mission and Battle Management Command and Control mission
5. Complete and submit to DOT&E for approval a new CEC TEMP that describes the test strategy for CEC Block II.

CVN 78 *Gerald R. Ford*-Class Nuclear Aircraft Carrier

Executive Summary

- The DOT&E assessment of CVN 78 remains consistent with previous assessments. Poor or unknown reliability of new technology systems critical for flight operations, including newly designed catapults, arresting gear, weapons elevators, and radar, could adversely affect CVN 78's ability to generate sorties. Reliability of these critical subsystems poses the most significant risk to the CVN 78 IOT&E timeline.
- CVN 78 completed its Post Shakedown Availability (PSA) on October 25, 2019. CVN 78 entered the shipyard for the PSA in July 2018 after completing eight Independent Steaming Event (ISE) at-sea periods.
- Since the PSA ended, CVN 78 completed 11 ISEs through September 2020 that addressed a variety of certification and testing requirements. The ISEs included embarkation of the Air Wing and testing of various systems.
- The new weapons elevators on CVN 78 remain behind schedule. The Navy has only accepted 6 of the 11 elevators for use, and expects to accept the remaining elevators installed by 3QFY21.
- Based on ISE results, the reliability of the catapults and arresting gear remain well below their requirements. Reliability of the weapons elevators remains unknown.
- CVN 78 is unlikely to achieve the Sortie Generation Rate (SGR) (number of aircraft sorties per day) requirement. Unrealistic assumptions underpin the SGR threshold requirement. These assumptions ignore the effects of weather, aircraft emergencies, ship maneuvers, and current Air Wing composition on flight operations. DOT&E plans to assess CVN 78 performance during IOT&E by comparing it to the demonstrated performance of the *Nimitz*-class carriers, as well as to the SGR requirement.
- CVN 78 will likely be short of berthing spaces, and may require berthing modifications to accommodate the specific mix of personnel embarked.
- The Navy conducted one operational test for the CVN 78 combat system in FY20. To date, the Navy has conducted two of the four planned CVN 78 operational test events on the Self-Defense Test Ship (SDTS) phase of testing, and has not resourced the two remaining phases of combat system operational testing.
- Deviations from the Navy's 2006 Air Warfare Enterprise construct that leveraged combat system commonalities to share test events, costs, and resources between DDG 1000 and CVN 78 have resulted in a resource-limited CVN 78 Air Warfare test campaign. DOT&E expects the Navy to conduct an adequate Air Warfare test campaign on CVN 79 to fully characterize the performance of the CVN 79 combat system. The CVN 79 Air Warfare testing is also intended to inform future CVN 78 performance once the Navy makes planned changes to the CVN 78 combat system.
- CVN 78 exhibits electromagnetic compatibility problems experienced by new classes of ships and is working to resolve the issues. The Navy continues to characterize the problems and develop mitigation plans.
- The Navy continues to conduct the LFT&E program to provide the data and analyses required for the evaluation of the ship's survivability against operationally significant kinetic threats.

System

- The CVN 78 *Gerald R. Ford*-class aircraft carrier program introduces a new class of nuclear-powered aircraft carriers. It uses the same hull form as the CVN 68 *Nimitz*-class but introduces a multitude of new ship systems.
- The new nuclear power plant reduces manning levels compared to a *Nimitz*-class ship and produces significantly more electricity. CVN 78 uses the increased electricity (instead of steam) to power electromagnetic catapults and arresting gear, both designed to increase reliability and expand the aircraft launch and recovery envelopes.
- The Navy redesigned weapons elevators, handling spaces, and stowage to reduce manning, improve safety, and increase weapon throughput. Weapon elevators use electromagnetic linear induction motors instead of cable-driven systems.
- CVN 78 incorporates a more efficient flight deck layout, dedicated weapons handling areas, and an increased number of aircraft refueling stations designed to enhance its ability to launch, recover, and service aircraft.
- The CVN 78 combat system incorporates changes intended to improve upon the legacy *Nimitz*-class combat system. It consists of:
  - A phased-array Dual Band Radar (DBR) comprised of the SPY-4 Volume Search Radar (VSR) and the SPY-3 Multi-Function Radar (MFR). The DBR replaced several

legacy radars used on current carriers for self defense and air traffic control.
- Ship Self-Defense System (SSDS) Mark 2 command decision system.
- Cooperative Engagement Capability (CEC) tracking and data fusion and distribution system.
- SLQ-32(V)6 electronic surveillance system equipped with Surface Electronic Warfare Improvement Program (SEWIP) Block 2.
- Rolling Airframe Missile (RAM) Block 2 and Evolved Sea Sparrow Missile (ESSM) Block 1.
- Phalanx Close-In Weapon System (CIWS).

- The follow-on *Ford*-class aircraft carrier, CVN 79, will have several significant updates to the ship systems, including:
  - Enterprise Air Surveillance Radar (EASR/SPY-6(V)3), along with SPQ-9B and MK 9 Tracking Illuminators, will replace CVN 78's DBR.
  - New capability build SSDS Mark 2 command decision system.
  - SLQ-32(V)6 electronic surveillance system equipped with the Soft Kill Coordination System.
  - RAM Block 2A or 2B variants intended to improve performance against anti-ship cruise missile (ASCM) attack.
  - ESSM Block 2 with an active-all-the-way seeker that could engage ASCMs without the MK 9 tracking illumination radars.
  - CIWS integrated with CEC and SSDS to achieve a fully integrated ship self-defense against ASCMs.
- The ship includes the following enhanced survivability features:
  - Improved protection for magazines and other vital spaces
  - Shock-hardened mission systems/components
  - Installed and portable damage control, firefighting, and dewatering systems intended to expedite response to and recovery from peacetime fire, flooding, and battle damage
- CVN 78 includes a new Heavy Underway Replenishment system capable of transferring cargo loads of up to 12,000 pounds.
- The Navy intends to achieve CVN 78 Initial Operational Capability in FY21 prior to the start of Full Ship Shock Trial (FSST) and Full Operational Capability in FY24 after successful completion of IOT&E and Type Commander certification.

Mission

Carrier Strike Group Commanders will use CVN 78 to:
- Conduct power projection and strike warfare missions using embarked aircraft
- Provide force and area protection
- Provide a sea base as both a command and control platform and an air-capable unit

Major Contractor

Huntington Ingalls Industries, Newport News Shipbuilding – Newport News, Virginia

---

Activity

- The Navy updated the Test and Evaluation Master Plan (TEMP) 1610 and routed Revision D. This TEMP Revision continues two back-to-back phases of initial operational testing described in previous annual reports. Phase One focuses on routine unit-level operations and the ship's internal workings (including cyclic flight operations with an embarked Air Wing). Phase Two focuses on more complex evolutions, including tests of the integrated combat system in self-defense scenarios, and integrated operations with an embarked Air Wing, Destroyer Squadron, and Carrier Strike Group staffs during the Composite Training Unit Exercise (COMPTUEX) at-sea period. The Navy will examine sustained SGR in the COMPTUEX and surge SGR before the ship's second deployment. TEMP Revision D also outlines the Navy's cybersecurity strategy for CVN 78.
- The coronavirus (COVID-19) pandemic did not impact T&E.

Electromagnetic Aircraft Launch System (EMALS)

- The Navy issued the final EMALS Aircraft Launch Bulletins, required for shipboard operations, at the end of 2019.
- Post PSA, through ISE 11, CVN 78 has launched 3,975 aircraft.

Advanced Arresting Gear (AAG)

- The Navy released the final Aircraft Recovery Bulletins on August 2, 2019. These bulletins are required for shipboard flight operations with fleet aircraft.
- Post PSA, through ISE 11, CVN 78 has recovered 3,975 aircraft.

Advanced Weapons Elevators (AWE)

- The development, installation, and delivery of the AWE remain behind schedule. As of September 2020, CVN 78 had all 11 elevators installed, but the Navy has certified only 6 for use.

Combat System

- The Navy conducted one of the remaining three CVN 78 operational tests planned on the SDTS in the DOT&E-approved CVN 78 test plan and the DOT&E-approved Capstone Enterprise Air Warfare Ship Self-Defense TEMP. The Navy originally scheduled this event for May 2019, but delayed it repeatedly until its execution in August 2020. The reasons for these delays varied, but were generally related to a lack of developmental testing prior to operational testing, which would have built confidence in combat system performance as well as in the ability of the test range to successfully execute the event. The Navy has delayed one other CVN 78 SDTS test several times; this event, originally planned for October 2019, is scheduled for December 2020. The Navy canceled the one remaining test, the last of the three outstanding CVN 78 events on the SDTS, because the Navy did not incorporate software changes required to conduct the test on SDTS.

- The Navy has not identified funding for combat system testing on CVN 78 or for the modeling and simulation (M&S) suite required to support evaluation of the ship's Probability of Raid Annihilation (PRA) requirement.
- EASR is in developmental testing at the Wallops Island Engineering Test Center, Virginia. The Navy intends to begin combat system integration efforts in FY21.

Live Fire Test & Evaluation

- The Navy continues to plan the CVN 78 FSST and is on track to conduct it in 3Q/4QFY21.
- In 1QFY19, the Navy delivered the Vulnerability Assessment Report detailing an assessment of the ship's survivability to air-delivered threat engagements. The classified findings in the report identify the specific equipment that most frequently would lead to mission capability loss in such engagements.
- The Navy delayed the delivery of an additional report volume intended to detail an assessment of the ship's survivability against underwater threats (and compliance with Operational Requirements Document survivability criteria) to FY21 due to problems with the M&S tool used in the evaluation.

Assessment

- As noted in previous annual reports, the test schedule has been aggressive. The extension in PSA delayed both phases of initial operational testing until FY22.
- TEMP Revision D outlines the Navy's cybersecurity strategy to test CVN 78, but has not translated the strategy into an actionable test plan.

Reliability

- Four of CVN 78's new systems stand out as critical to flight operations: EMALS, AAG, DBR, and AWE. Overall, the low reliability demonstrated by AAG, EMALS, and DBR, along with the uncertain reliability of AWE, could further delay the CVN 78 IOT&E. Reliability estimates derived from test data for EMALS, AAG, and DBR are discussed in following subsections. For AWE, preliminary reliability estimates have been provided on 6 of the 11 elevators, the only ones certified.

EMALS

- The delivery of the EMALS launch bulletins allows CVN 78 to launch all aircraft in the ship's Air Wing.
- During the 3,975 catapult launches conducted post PSA through ISE 11, EMALS demonstrated an achieved reliability of 181 mean cycles between operational mission failure (MCBOMF), where a cycle is the launch of one aircraft. This reliability is well below the requirement of 4,166 MCBOMF.
- During ISE 8, two separate failures caused individual EMALS catapults to go down for 3 days. One of the failures was attributed to a legacy component.
- The reliability concerns are exacerbated by the fact that the crew cannot readily electrically isolate EMALS components during flight operations due to the shared nature of the Energy Storage Groups and Power Conversion Subsystem inverters on board CVN 78. The process for electrically isolating equipment is time-consuming; spinning down the EMALS motor/generators takes 1.5 hours by itself. This inability precludes EMALS high power maintenance during flight operations.

AAG

- Through the first 3,975 recoveries, AAG demonstrated an achieved reliability of 48 MCBOMF, where a cycle is the recovery of a single aircraft. This reliability estimate falls well below the requirement of 16,500 MCBOMF.
- While in port prior to ISE 9, during maintenance troubleshooting, the AAG system experienced a failure of an Energy Storage Capacitor Bank, which rendered all three engines inoperative. It took the Navy 7 days to investigate the failure and bring AAG back into service by mechanically isolating the failed capacitor bank. The failed parts were repaired during a later in-port period.
- The reliability concerns are magnified by the current AAG design that does not allow electrical isolation of the Power Conditioning Subsystem equipment from high power buses, limiting corrective maintenance on below-deck equipment during flight operations.

Combat System

- Post-PSA sea-based developmental test events show the DBR still experiences clutter tracks, but to a smaller extent and of a different origin than previously reported. The events also show that CEC, in certain conditions, provides inaccurate tracking of air contacts. During these events, SEWIP Block 2 created undesired emitter tracks that could cause the ship to expend more ESSMs and RAMs than necessary to destroy incoming threats.
- The Navy is satisfied with the DBR track support for Air Traffic Control (ATC) after post-PSA at-sea testing. The DBR successfully suppresses the disclosure of the majority of environmental tracks when it sends tracks to TPX-42. The Navy does not plan to conduct any further ATC-type aircraft flights during sea-based developmental testing.
- During the August 2020 missile firing operational test on SDTS, the system demonstrated good tracking performance of the targets by MFR and CEC, and good engagement support by the SSDS MK 2 Mod 6 element, which correctly provided scheduling and weapon assignments. SEWIP Block 2 emitter reporting interfered with optimal engagements against threats. Several problems contributed to the failure of some ESSMs and RAMs to destroy their intended targets.

- Results of live testing completed to date indicate that CVN 78 has limited self-defense capability against ASCM surrogates, but several challenges persist with respect to the efficacy of the ship's combat system.
- Post PSA through ISE 11, DBR demonstrated a mean time between operational mission failures (MTBOMF) of 100 hours, below the requirement of 339 hours.
- Preliminary results of EASR's early developmental testing indicate that electromagnetic interference, tracking performance, electronic protection, and power compliance testing are focal areas for ongoing system developmental work and improvements. Until operationally relevant reliability data are supplied to DOT&E, system reliability remains a significant risk area for EASR. EASR's combat system integration remains untested.
- Planned operational tests of the CVN 78 combat system continue to be delayed or have been canceled. In the 2006 Capstone Enterprise Air Warfare Ship Self-Defense TEMP, the Navy planned to leverage commonality between the DDG 1000 and CVN 78 combat systems to reduce the number of operational test events conducted on each ship. However, subsequent changes to the DDG 1000 combat system reduced commonality between the two ships and negated the ability to leverage testing and resources across the two combat systems.
- DOT&E recognizes that the CVN 78 Air Warfare test program is resource-limited because the Enterprise Air Warfare approach was not executable due to the divergence of the DDG 1000 and CVN 78 combat systems. DOT&E accepts this limitation expecting that the Navy will plan and execute an adequate air warfare test program for CVN 79. The CVN 79 test campaign is also intended to inform CVN 78 combat system performance once it is retrofitted with planned changes.

SGR

- CVN 78 is unlikely to achieve its SGR requirement. The target threshold is based on unrealistic assumptions including fair weather and unlimited visibility, and that aircraft emergencies, failures of shipboard equipment, ship maneuvers, and manning shortfalls will not affect flight operations. During the 2013 operational assessment, DOT&E conducted an analysis of past aircraft carrier operations in major conflicts. The analysis concludes that the CVN 78 SGR threshold requirement is well above historical levels.
- DOT&E plans to assess CVN 78 performance during IOT&E by comparing it to the SGR requirement, as well as to the demonstrated performance of the *Nimitz*-class carriers.
- Poor reliability of key systems that support sortie generation on CVN 78 could cause a cascading series of delays during flight operations that would affect CVN 78's ability to generate sorties. The poor or unknown reliability of these critical subsystems represents the most risk to the successful completion of CVN 78 IOT&E.

Manning

- Reduced manning requirements drove the design of CVN 78. The berthing capacity is 4,660, or 1,100 fewer than *Nimitz*-class carriers. Based on current expected manning, the berthing capacity for officers and enlisted will be exceeded with some variability in the estimates depending on the specific scenario examined.

Electromagnetic Compatibility

- Developmental testing identified significant electromagnetic radiation hazard and interference problems. The Navy implemented some mitigation measures and conducted follow-on characterization testing during ISEs, but some operational limitations and restrictions are expected to persist into IOT&E and deployment. The Navy will need to develop capability assessments at differing levels of system use in order for commanders to make informed decisions on system employment.

Live Fire Test & Evaluation

- In FY20, the Navy continued with the shock qualification testing of CVN 78 components to support the survivability evaluation of CVN 78 to underwater threat engagements. Due to scarcity of test assets, some components and systems (e.g., DBR) will not be shock qualified before the FSST.
- Adequate use of M&S in the vulnerability evaluation of the ship against underwater threats is at risk. Challenges with the Navy Enhanced Sierra Mechanics M&S tool prompted the Navy to switch back to the Dynamic Systems Mechanics Advanced Simulation M&S tool to complete the vulnerability assessment report. While necessary, the change will require additional verification and validation to ensure the credibility of the survivability evaluation.

Recommendations

The Navy should:

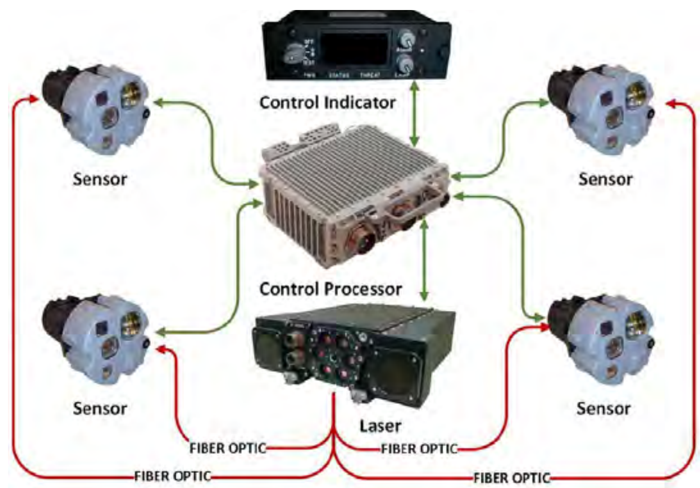
1. Continue to characterize the electromagnetic environment on board CVN 78 and develop operating procedures to maximize system effectiveness and maintain safety. As applicable, the Navy should use the lessons learned from CVN 78 to inform design modifications for CVN 79 and future carriers.
2. Implement the required software changes to multiple combat system elements to allow cueing from external sources necessary to conduct one of the two remaining SDTS test events.
3. Conduct both remaining SDTS combat system test events for CVN 78.
4. Correct the cause of combat system failures that led to ESSMs and RAMs missing their intended targets, and demonstrate the correction in a future phase of operational testing.
5. Fund the CVN 78 lead ship combat system operational testing and the M&S suite required to support assessment of the CVN 78 PRA requirement.

6. Conduct an operational assessment of EASR at Wallops Island, Virginia. This testing should evaluate EASR's contributions to the air traffic control and self-defense missions, as well as provide an early assessment of electromagnetic interference and radiation hazard concerns.
7. Update TEMP 1610 to include cybersecurity testing on CVN 78 and CVN 79 testing driven by the changes to the ship's combat system, including the introduction of EASR.
8. Complete validation of the M&S tools supporting the LFT&E assessment, including comparison of the FSST data to relevant M&S predictions.
9. Continue to improve availability and reliability for EMALS, AAG, DBR, and AWE.

Distributed Aperture Infrared Countermeasure System (DAIRCM)

Executive Summary

- The Marine Corps made its fielding decision for the Distributed Aperture Infrared Countermeasure (DAIRCM) system in the Joint Urgent Operational Needs (JUON) configuration on the AH-1Z and UH-1Y in February 2020.
- Results from Marine Corps and Navy testing showed that the hardware and software version of the DAIRCM system installed on the MH-60S, UH-1Y, and AH-1Z had the capability to defeat the required man-portable air-defense systems (MANPADS) threat identified in the JUON Statement SO-0010 dated March 30, 2015. The system defeated vehicle-launched infrared-guided missiles and other MANPADS and had the capability to detect laser-guided threats and hostile fire.



System

- The DAIRCM system is an integrated suite of missile warning, laser warning, hostile fire indicator, and infrared countermeasure components designed to protect rotary-wing aircraft from the threat posed by infrared missiles.
- The system uses a single, centrally installed laser that provides laser energy to a selected sensor where an integrated Laser Pointer Module directs it towards the declared threat. The threat warning sensor sends raw video and digital data information to the processor, which analyzes the data for an incoming Missile, Laser, or Hostile Fire threat. If the processor detects a threat, it notifies the aircrew through the control interface unit and provides the proper countermeasure against the incoming missile, if applicable.
- The Navy's Program Office for Advanced Tactical Aircraft Protection Systems, PMA-272, is the lead for developing the DAIRCM system.

Mission

During missions, the DAIRCM system is intended to provide automatic protection for rotary-wing aircraft against shoulder-fired, vehicle-launched, and other infrared-guided missiles.

Major Contractors

- Leonardo Digital/Retrieval Systems (DRS) Infrared Sensors and Systems – Dallas, Texas
- Leonardo DRS Daylight Solutions – San Diego, California

Activity

- The Marine Corps and Navy completed testing for the Quick Reaction Assessment (QRA) for the DAIRCM JUON on the MH-60S and AH-1Z helicopters using operational flight program (OFP) version 2134 at Eglin AFB, Florida, in October 2019.
- The Navy conducted QRA testing for the MH-60S, UH-1Y, and AH-1Z in accordance with the DOT&E-approved test plan.
- The Navy completed the verification and validation of the digital system model for DAIRCM in November 2019.
- The Commander, Operational Test Force completed his classified AH-1Z QRA Interim report in January 2020.
- DOT&E completed a classified QRA report on the MH-60S and the AH-1Z in February 2020.
- The Marine Corps made its fielding decision for the DAIRCM system on the AH-1Z and the UH-1Y in February 2020.
- The Navy completed QRA testing on the MH-60S with OFP version 2135 at HSC-26, Norfolk Naval Station, Virginia, and Webster Field, Maryland, in March 2020.
- The Navy completed QRA testing on the UH-1Y with OFP version 2135 at Webster Field, Maryland, in June 2020.
- The Air Force completed testing on the HH-60G with OFP version 2135 at Nellis AFB, Nevada, in July 2020.
- The coronavirus (COVID-19) pandemic caused delays in data analysis and reporting due to personnel having limited access to systems necessary to process classified data and related information.

Assessment

- The Navy corrected deficiencies identified during JUON testing of OFP 2134 on the MH-60S and AH-1Z resulting in the release of OFP 2135.

- Results showed that the DAIRCM system, as installed on the MH-60S, UH-1Y, and AH-1Z with OFP 2135, has the following capabilities:
  - Defeat the required MANPADS threat identified in the JUON Statement SO-0010 dated March 30, 2015.
  - Defeat vehicle-launched infrared-guided missiles and other MANPADS.
  - Detect laser-guided threats and hostile fire.

Recommendations

None.

E-2D Advanced Hawkeye

Executive Summary

- The Navy completed E-2D operational testing for Delta System/Software Configuration (DSSC) Build 3 upgrades in FY20 and demonstrated an initial aerial refueling (AR) capability.
- The classified DOT&E DSSC-3 FOT&E report, signed on July 27, 2020, noted improved Naval Integrated Fire Control (NIFC) capabilities, but assessed shortfalls in reliability, availability, and logistic supportability.

System

- The E-2D Advanced Hawkeye is a carrier-based airborne early warning and command and control aircraft.
- Significant changes to this variant of the E-2 include: upgraded engines to provide increased electrical power and cooling relative to current E-2C aircraft; a strengthened fuselage to support increased aircraft weight; replacement of the radar system, communications suite, and mission computer; and incorporation of an all-glass cockpit, which permits the co-pilot to act as a tactical fourth operator.
- The radar upgrade replaces the E-2C mechanically scanned radar with a phased-array radar that has combined mechanical and electronic scan capabilities. The upgraded radar is designed to improve littoral and overland detection performance and Theater Air and Missile Defense capabilities.
- The E-2D Advanced Hawkeye Program includes all simulators, interactive computer media, and documentation to conduct maintenance, as well as aircrew shore-based initial and follow-on training.
- DSSC-3 included the Automated Identification System, Mode 5 Interrogator, Embedded National Tactical Receiver, Automatic Dependent Surveillance-Broadcast, Accelerated Mid-Term Interoperability Improvement Program, NIFC improvements, and the introduction of AR.

Mission

Combatant Commanders will use the E-2D Advanced Hawkeye, whether operating from the aircraft carrier or from land, to accomplish the following missions:

- Theater air and missile detection and early warning
- Battlefield management, command, and control
- Acquisition, tracking, and targeting of surface warfare contacts
- Surveillance of littoral area objectives and targets
- Tracking of strike warfare assets

Major Contractor

Northrop Grumman Aerospace Systems – Melbourne, Florida

Activity

- The Navy completed the third FOT&E period (OT-D3) from March 2019 through January 2020 in accordance with the DOT&E-approved test plan for effectiveness and suitability evaluations. The test focused on DSSC-3 software and hardware upgrades and the introduction of AR.
- The Navy did not complete operational cybersecurity testing during OT-D3 as required by the DOT&E-approved Test and Evaluation Master Plan Revision E.
- The Navy conducted cybersecurity testing in 1QFY21.

Assessment

- E-2D AR testing in FY20 demonstrated the platform can effectively conduct AR with fixed-wing tankers, to include the F/A-18E/F, during daytime operations. Although the Navy did not conduct night AR testing with F/A-18 E/F during the operational testing period, the E-2D successfully accomplished night AR with strategic tankers.
  - AR provides a dramatic increase in operational range, endurance, and safety at sea.
  - Improving operator comfort on long endurance flights and expanding the AR envelope to include additional altitudes, airspeeds, and tanking platforms will give commanders more flexibility at sea.
- As detailed in the DOT&E classified DSSC-3 FOT&E report, operational test results demonstrated an increase in NIFC capabilities.
- DSSC-3 operational test data reinforce previous DOT&E assessments that noted shortfalls in radar reliability, aircraft availability, and logistic supportability.

Recommendations

The Navy should:

1. Increase radar and aircraft reliability in order to improve suitability.
2. Increase the operational AR flight clearance envelope to give operational commanders more flexibility at sea.

F/A-18E/F Super Hornet

Executive Summary

- The Navy released System Configuration Set (SCS) H14 in September 2019 for use in the F/A-18E/F Super Hornet and EA-18G Growler fleets, and utilized that software throughout 2020. The Navy completed operational testing of SCS H14+ in 1QFY21 but has not yet released it to the fleet.
- DOT&E concluded that SCS H14 added operational capabilities to the Super Hornet and that the F/A-18E/F is operationally suitable in a classified report signed in June 2020.
  - The Super Hornet demonstrated improved Naval Integrated Fire Control (NIFC) – Counter Air (CA) capabilities.
  - The active electronically scanned array (AESA) radar did not meet reliability requirements.
- The Navy did not complete the operational cybersecurity testing required by the H14 Test and Evaluation Master Plan (TEMP).
- Developmental challenges resulted in the Navy delaying the start of operational testing of SCS H16 for Block II aircraft from September 2020 to January 2021; however, integrated testing began 1QFY21. SCS H16 will introduce the following capability upgrades and enhancements: AESA electronic protection improvements, NIFC improvements, net-enabled weapons (NEW) improvements, Infrared Search and Track (IRST) Block II integration, Integrated Defensive Countermeasures (IDECM) suite improvements, and mission planning improvements.
- The Navy took delivery of its first two Block III F/A-18E/F developmental test aircraft in June 2020.

System

- The F/A-18E/F Super Hornet is the Navy's follow-on replacement to the F/A-18A/B/C/D and the F-14.
- F/A-18E/F Super Hornet Block II hardware includes the APG-79 radar (Lots 26+), Advanced Targeting Forward Looking Infrared pod, Multifunctional Information Distribution System for Link 16 tactical datalink connectivity, Joint Helmet Mounted Cueing System, and IDECM. The software enables the F/A-18E/F to perform single-pass multiple targeting for GPS-guided weapons, and allows for the use of off-board target designation, improved datalink for target coordination precision, and the implementation of air-to-ground target aim points.
- F/A-18E/F Super Hornet Block III acquisition includes the purchase of new aircraft and the retrofit of Block II airframes. Improvements planned include an Advanced Network Infrastructure that consists of a Tactical Targeting Network Technology (TTNT) and a Distributed Targeting Processor-Networked (DTP-N), a second Generation 5 radio, high-definition video recording, Advanced Cockpit System, Common Tactical Picture, reduced radar cross section, and airframe extension to 10,000 flight hours.

System Configuration Set Software (SCS)

- Super Hornet aircraft include SCS operational software, the periodic update of which enables major combat capability enhancements.
  - F/A-18E/F (prior to Lot 25) aircraft use "X-series" software. The Navy released SCS 25X on legacy Hornet and older Super Hornet aircraft in October 2015.
  - F/A-18E/F (production Lot 25+) Block 2 aircraft use high-order language software. The Navy completed operational testing of SCS H14 in January 2020, SCS H14+ in 1QFY21, and plans to begin operational testing of SCS H16 for Block II aircraft in early 2021.
- SCS H16 for F/A-18E/F Block II will introduce the following capability upgrades and enhancements: AESA electronic protection improvements, NIFC improvements, NEW improvements, IRST Block II integration, IDECM improvements, and mission planning improvements. The Navy plans for the same capabilities, as well as an Advanced Network, to be included in Block III SCS H16.

Mission

Combatant Commanders use the F/A-18E/F to:

- Conduct offensive and defensive counter-air combat missions
- Attack ground targets with most of the U.S. inventory of precision and non-precision weapons
- Provide organic in-flight refueling to the Carrier Strike Group
- Provide the fleet with an organic tactical reconnaissance capability

Major Contractors

- The Boeing Company, Integrated Defense Systems – St. Louis, Missouri
- Raytheon Company – Forest, Mississippi
- General Electric Aviation – Evendale, Ohio
- Northrop Grumman Corporation – Bethpage, New York
- Lockheed Martin – Orlando, Florida

Activity

- DOT&E approved the F/A-18E/F SCS H14 TEMP on February 1, 2019. The Navy operationally tested SCS H14 in accordance with the DOT&E-approved TEMP, completing in January 2020.
- DOT&E approved the SCS H14+ test plan in June 2020. H14+ testing was executed in accordance with the test plan in August 2020.
- The coronavirus (COVID-19) pandemic delayed the completion of the DOT&E classified report of SCS H14 FOT&E to June 2020 due to limited access to computer authoring and analysis tools.
- The Navy was required to submit a separate cybersecurity test plan for DOT&E approval, but did not do so. However, the Navy incorporated cybersecurity test considerations in the SCS H16 TEMP and test plan.
- Developmental challenges resulted in the Navy delaying the start of operational testing of SCS H16 for Block II aircraft from September 2020 to January 2021, although integrated testing commenced in 1QFY21. DOT&E approved the Block II SCS H16 TEMP and test plan in 1QFY21, and the Navy plans to conduct an Operational Test Readiness Review in 2QFY21.
- Fleet release of SCS H16 is anticipated 4QFY21.
- The Navy took delivery of its first two Block III F/A-18 E/F developmental test aircraft in June 2020. Block III acquisition will include both the purchase of new airframes and the retrofit of Block II aircraft.

Assessment

- DOT&E completed its assessment of SCS H14 operational testing and published a classified operational test report in June 2020. DOT&E noted the following:
  - Analysis validated SCS H14 improvements to the F/A-18E/F's operational capability. The AESA radar did not meet reliability requirements.
  - The Navy's data are not sufficient to assess F/A-18 E/F performance. The Service operational test agencies need to fully embrace existing data collection and analysis techniques to adequately account for emerging threat impacts on the rapidly evolving operational environment.
- The Navy has planned for the requirement to conduct an end-to-end, multiple AIM-120 missile test to demonstrate the AESA radar's ability to support this required capability; however, resource limitations have precluded execution.

Recommendations

The Navy should:

1. Allocate adequate resources for planning and conducting comprehensive Super Hornet cybersecurity operational testing.
2. Utilize more robust data collection and analysis methods during operational test events, to include continuous measures, to more adequately assess F/A-18 capability in the rapidly evolving threat environment.
3. Plan and resource end-to-end testing employing multiple AIM-120 missiles.

FFG 62 *Constellation* Class – Guided Missile Frigate

Executive Summary

- In April 2020, DOT&E approved the Guided Missile Frigate (FFG 62 *Constellation* Class) LFT&E Alternate Plan. This allowed the waiver from full-up system-level testing to be approved, which supported the Milestone B decision.
- In June 2020, DOT&E approved the FFG 62 *Constellation* class Test and Evaluation Master Plan (TEMP) with the exception of the plan's strategy for testing FFG 62 *Constellation* class anti-air warfare (AAW) mission capability, which was not approved and deferred until the next TEMP update, scheduled for FY24.

System

- The FFG 62 *Constellation* class is a new multi-mission, small surface combatant intended to operate in increasingly complex warfare environments requiring capability to conduct air warfare (AW); anti-submarine warfare (ASW); surface warfare (SUW); electronic warfare (EW)/information operations (IO); and intelligence, surveillance, and reconnaissance (ISR) missions.
- The ship is powered by a combined diesel-electric and gas system, which employs two electric propulsion motors and a single gas turbine engine.
- The key Navy standard warfare system elements to be fielded on board FFG 62 *Constellation* class include the following systems:
  - AN/SPY-6 (FFG 62 *Constellation* class variant) Air Surveillance Radar
  - Mk 41 Vertical Launch System with Evolved Sea Sparrow Missiles and Navy Standard Missiles
  - Rolling Airframe Missile (RAM) Guided Missile Launching System with RAM
  - AN/SQQ-89(V)16 Undersea Warfare/ASW Combat System
  - AN/SLQ-25 NIXIE
  - AN/SPS-73(V)18 Next Generation Surface Search Radar
  - Mk 110 57-mm Gun (with Advanced Low-Cost Munitions Ordnance)
  - Over-the-Horizon Weapon System
  - MH-60R Seahawk helicopter
  - MQ-8C Fire Scout Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle with MD-4A Mission Control System

- The FFG 62 *Constellation* Class System Specification establishes requirements for survivability features to be incorporated into the ship. They include, but are not limited to, the following:
  - Shock resistance to underwater explosions for select systems
  - Armor and ballistic protection in designated areas
  - Blast and fire-resistant structure in designated areas
  - Vulnerability reduction features for vital hull, mechanical, and electrical systems to include redundancy, separation, and damage isolation
  - Chemical, biological, and radiological defense systems
  - Signature reduction (e.g. radar cross section (RCS), infrared (IR), underwater electromagnetic)

Mission

The Maritime Component Commander will employ FFG 62 *Constellation* class to conduct AW, ASW, SUW, EW/IO, and ISR missions to support the National Defense Strategy across the full range of military operations.

Major Contractor

Fincantieri Marinette Marine Corporation – Marinette, Wisconsin

Activity

- In June 2020, DOT&E approved the FFG 62 *Constellation* class TEMP with the exception of the plan's strategy for testing FFG 62 *Constellation* class AAW mission capability. DOT&E did not approve the AAW test strategy because it was not adequate to determine the operational effectiveness of the FFG 62 *Constellation* class combat system.

- In April 2020, DOT&E approved the FFG 62 *Constellation* class LFT&E Alternate Plan to allow the program to seek a waiver from full-up system-level testing and complete Milestone B requirements. The FFG 62 *Constellation* class LFT&E Alternate Plan includes Full Ship Shock Trials as a primary method to evaluate the FFG 62 *Constellation* class survivability to threat-induced shock. The approved plan retains the option to plan and execute an alternative to Full Ship Shock Trials should DOT&E, in coordination with the Navy, review and approve such an alternative as adequate prior to the next TEMP update, scheduled for FY24.
- The Navy established a working group to mature the Enhanced Testing supported by Modeling and Simulation (ET-M&S) approach proposed as an alternative to Full Ship Shock Trials.
- In September 2020, the FFG 62 *Constellation* class Program Office completed the first test series in the LFT&E program. Testing, executed at Aberdeen Test Center, Maryland, supplied the ballistic penetration data required for model verification and validation.

Assessment

- The Navy's proposed AAW strategy intends to leverage the results of future Aegis Destroyer (DDG 51 Flight III)-related test programs to evaluate FFG 62 *Constellation* class AAW capabilities. The Navy's justification for this approach depends on similarities between some elements of the FFG 62 *Constellation* class and DDG 51 Flight III combat system, but they do not address how end-to-end mission performance of the DDG 51 Flight III combat system can be extrapolated to evaluate the end-to-end mission performance of the FFG 62 *Constellation* class combat system.
- The successful execution of the Navy's approach is also predicated on successfully managing substantial test and schedule interdependencies of at least five distinct Navy acquisition programs that are not yet documented, resourced, or approved by the Navy or DOT&E in program TEMPs. These programs are Enterprise Air Surveillance Radar, Aegis Weapons System (as installed on DDG 51 Flight III), Standard Missile 2 Block IIIC, Enhanced Sea Sparrow Missile Block 2, and RAM Block 2A/2B. The Navy's proposed AAW approach is not adequate without strategies for managing these interdependencies and addressing end-to-end performance differences between combat systems, and without documentation of critical details on the test scope, assets, resources, and schedule required to support successful test execution.
- The Navy has committed to updating the FFG 62 *Constellation* class TEMP by the end of FY24. As the TEMP states, critical Aegis testing will not conclude until 4QFY24. DOT&E encouraged the Navy to complete the TEMP update with the subset of Aegis data that are available and have been evaluated for FFG 62 *Constellation* class applicability by that time.
- The Navy expects to complete Aegis testing in 4QFY24. DOT&E will work with the Navy to evaluate those results to determine whether the FFG 62 *Constellation* class T&E Strategy will require unmanned ship testing. If the requisite data are not available and/or applicable to FFG 62 *Constellation* class, unmanned ship testing will need to be resourced and scheduled in the Navy's FY24 TEMP update.
- The FFG 62 *Constellation* class LFT&E program includes a number of M&S upgrades and surrogate tests to address long-standing limitations in the Navy's vulnerability assessment toolset. If successful, the FFG 62 *Constellation* class vulnerability assessments will include new blast loading, fragment penetration, near-contact underwater explosion shock prediction, and whipping analysis that will enable a more comprehensive and accurate assessment of the ship's survivability performance.
- The ET-M&S approach could potentially enable a more comprehensive assessment of the ship's response to shock and in a timeframe that would enable the findings to be efficiently implemented into the design. To effectively use this approach in lieu of Full Ship Shock Trials, a Navy-wide effort is required to adequately predict and validate the damage tolerance and likely failure modes of naval equipment and systems when exposed to underwater shock.

Recommendations

The Navy should:

1. Start working on FFG 62 *Constellation* class TEMP updates as soon as possible to ensure the TEMP is completed by the end of FY24. The updated TEMP should identify the remaining data elements required to assess FFG 62 *Constellation* class AAW capabilities, and incorporate test events, test assets, and test resources required to complete the evaluation of FFG 62 *Constellation* class AAW mission capability. The updated TEMP should also include an overall integrated Master Test Schedule managing the remaining programmatic interdependencies required for the successful execution of the Navy's intended AAW operational test strategy.
2. Continue efforts to complete Aegis testing events intended to provide evaluation data necessary to determine whether the FFG 62 *Constellation* class T&E Strategy will require unmanned ship testing. If the requisite data are not available and/or applicable to FFG 62 *Constellation* class, the Navy should resource and schedule unmanned ship testing in the Navy's FY24 TEMP update.
3. Support the funding of ET-M&S to include development of a method of predicting principle unit failure due to underwater shock and demonstration of the validity of underwater shock M&S predictions.

Littoral Combat Ship (LCS)

Executive Summary

- In July 2020, DOT&E issued an operational test report on the *Freedom* variant equipped with the Surface Warfare (SUW) Increment 3 Mission Package (MP), based on the results of operational testing from July 2018 to June 2019.
- In November 2019, the Navy conducted an operational assessment on the Unmanned Influence Sweep System (UISS) as part of the Mine Countermeasures (MCM) MP. See the UISS Annual Report article on page 169 for details.
- In December 2019, the Navy completed analysis of the lethality of Littoral Combat Ship (LCS) weapon systems against a spectrum of small boat threats.


***Freedom* Variant (LCS 1)**


***Independence* Variant (LCS 2)**

System

Seaframes

- The LCS is designed to operate in shallow waters that limit the access of larger ships.
- The Navy is procuring two LCS seaframe variants:
  - The *Freedom* variant (odd-numbered ships) is a monohull design constructed of steel (hull) and aluminum (deckhouse) with two steerable and two fixed-boost waterjets driven by a combined diesel and gas turbine main propulsion system.
  - The *Independence* variant (even-numbered ships) is an aluminum trimaran with two steerable waterjets driven by diesel engines and two steerable waterjets driven by gas turbine engines.
- Both LCS variants are approximately the same size and displacement, though the composition, configuration, and arrangement of mission and auxiliary systems are different for each design.
- The LCS *Freedom* and *Independence* variant baselines will include a newly developed Light Weight Tow (LWT) to provide torpedo defense capability. However, the LWT is not funded.

Mission Packages

- LCS seaframes are designed to host specific warfare MPs. The Navy has installed individual MCM, SUW, and Anti-Submarine (ASW) MPs semi-permanently on the seaframes, dedicating specific ships to specific missions. The three MPs consist of the following components:

  SUW MP (including Increment 3--the final increment of SUW MP)
  - Gun Module: two MK 46 30-mm guns and one MK 110 Mod 0 57-mm gun.
  - Aviation Module: one MH-60S Armed Helicopter Weapon System and one MQ-8 Fire Scout.
  - Maritime Security Module: two 11-meter rigid-hull inflatable boats with launch and recovery equipment.
  - Surface-to-Surface Missile Module (SSMM): 24 Longbow HELLFIRE missiles modified for the maritime environment.

  MCM MP
  - Near Surface Detection Mission Module (MM): one Airborne Laser Mine Detection System unit for employment on the MH-60S multi-mission helicopter.
  - Remote Minehunting (RMH) MM: two minehunting sonar units and one MCM Unmanned Surface Vehicle (USV) for minehunting capabilities. The Navy is integrating the AN/AQS-20C minehunting sonar systems for use from the MCM USV. The Navy has implemented several Engineering Change Proposals to the UISS surface craft as the production baseline for the MCM USV.
  - Buried Minehunting MM: two battery-powered, autonomous, Knifefish Block I Unmanned Undersea Vehicles, employing a low frequency, broadband, synthetic aperture sonar to detect and classify mines moored in the ocean volume, laying on the ocean bottom, or buried in bottom sediment.
  - Coastal Mine Reconnaissance MM: one Coastal Battlefield Reconnaissance and Analysis System Block I

integrated with the MQ-8B Fire Scout. Fire Scout is a Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle for daytime unmanned aerial tactical reconnaissance to detect and localize mine lines and obstacles in the beach zone.
- Airborne Mine Neutralization MM: two Airborne Mine Neutralization System (AMNS) units for employment on the MH-60S multi-mission helicopter.
- Near Surface Neutralization MM (projected for FY24): the Barracuda Mine Neutralization System completed preliminary design review in June 2019. The system may begin developmental testing (DT) in FY24, and if successful, augment AMNS in other portions of the water column. The Navy plans to deploy Barracuda from LCS using the MCM USV.
- Unmanned Minesweeping MM: one UISS composed of one MCM USV and the sweep payload deployment system to detonate acoustic-, magnetic-, and combined acoustic/magnetic-initiated mines moored in the ocean volume, laying on the ocean bottom, or buried in bottom sediment.
- Aviation MM: consists of one MH-60S multi-mission helicopter with the AMCM mission kit and one MQ-8B Fire Scout.

ASW MP

- Escort Mission Module: multi-function towed array (MFTA) and variable depth sonar (VDS) with the AN/SQQ-89A(V)15 Surface Ship Undersea Warfare Combat System. MFTA and VDS provide submarine search, detection, localization, and track capability. MFTA also supports incoming torpedo detection and is the catalyst for LCS torpedo evasion.
- Aviation Mission Module: An MH-60R helicopter provides submarine prosecution capability with MK 54 torpedoes.

Mission

- The Maritime Component Commander will employ LCS to conduct MCM, ASW, or SUW tasks depending on the MP installed in the seaframe. Because of capabilities inherent to the seaframe, commanders can employ LCS in a maritime presence role with any MP supporting deterrence and maritime security operations. In addition, with the Maritime Security Module installed as part of the SUW MP, the ship can conduct Maritime Security Operations including Visit, Board, Search, and Seizure of ships suspected of transporting contraband.
- The Navy employs LCS alone or in company with other ships to prepare the environment for joint force access to critical littoral regions by conducting MCM, ASW, and SUW operations, possibly under an air defense umbrella.

Major Contractors

- *Freedom* variant
  - Prime: Lockheed Martin Maritime Systems and Sensors – Washington, D.C.
  - Shipbuilder: Marinette Marine – Marinette, Wisconsin
- *Independence* variant
  - Prime for LCS 6 and subsequent even-numbered ships: Austal USA – Mobile, Alabama
  - Shipbuilder: Austal USA – Mobile, Alabama

Activity

LCS Program

- The Navy has neither resourced nor conducted any air warfare test events against anti-ship cruise missile surrogates planned as part of the DOT&E-approved Capstone Enterprise Air Warfare Ship Self-Defense Test and Evaluation Master Plan (TEMP) or the LCS TEMP. The Navy's Program Executive Office for Integrated Warfare Systems halted all work to develop a Probability of Raid Annihilation (PRA) modeling and simulation (M&S) suite of the combat systems in FY15 and has not yet restarted the effort.
- The program is currently in the initial planning stages for conducting cybersecurity testing of the seaframes with the three mission packages.
- DOT&E is still working with the Navy to identify and resolve root causes of the poor statistical correlation between mine susceptibility M&S predictions and the data from the mine susceptibility trial conducted in 2019.

SUW

- The Navy completed DT of the SUW Increment 3 MP on the *Independence* variant in November 2019. Testing included radar tracking events and live missile firings against fast inshore attack craft (FIAC) surrogate targets. The testing culminated in a live-fire swarm attack defense event against 10 surrogate targets. This final event was designed as an integrated test event, to provide data for both the developmental and operational test programs. However, testing was not conducted in accordance with the DOT&E-approved test plan and was therefore not operationally representative.
- The Navy has not scheduled the final two small-boat swarm defense operational testing events required for the *Independence* variant equipped with the SUW Increment 3 MP due to the non-availability of surrogate targets, range time, and ship availability.
- In December 2019, the Navy completed Advanced Joint Effectiveness Model runs to support the lethality evaluation of the SSMM (part of Increment 3 of the SUW MP) against FIAC targets for a range of engagement conditions.

ASW

- In September 2019, the Navy embarked the ASW MP on board the LCS 3 to support DT. The Navy intended to complete DT in April 2020; however, several material failures delayed its completion. The Navy expects to complete DT in 1QFY21.

- The Navy intends to conduct operational testing in 2021.
- The Navy determined the risk of losing the towed body during operational testing of the torpedo evasion capability to be unacceptable. Although the likelihood of the towed body interacting with the incoming exercise torpedo during the test is low, the loss of the Navy's only test asset would significantly delay follow-on test events. Therefore, the Navy will conduct the torpedo evasion evaluation by simulating the towed body being deployed and prompting evasion based on historical capability of a similar torpedo detection system.
- The Navy deferred testing the search capability of LCS with ASW MP against diesel submarines (SSKs) and midget diesel submarines (SSMs) to FOT&E due to the unavailability of test assets during the planned IOT&E period.
- The Navy deferred testing the torpedo evasion capability of LCS with ASW MP against wake-homing torpedoes to FOT&E when an LWT is available for test.

MCM

- The Navy conducted an operational assessment on the UISS in November 2019. See the UISS Annual Report article on page 169 for details.
- The Navy continued integration of UISS and Knifefish components on the *Independence* variant throughout 2020 and began integration on the *Freedom* variant.

Assessment

SUW

- DOT&E issued a classified operational test report on the *Freedom* variant equipped with the SUW Increment 3 MP in July 2020 encompassing the results of testing from July 2018 to June 2019. The system was effective for defense against swarms of small boats at long ranges, but was not operationally suitable due to frequent ship propulsion failures. The classified operational test report has additional details.
- There has been no operational testing of the *Independence* variant equipped with the SUW Increment 3 MP. The integrated testing conducted in November 2019 was intended to inform DOT&E's evaluation, but deviations from the DOT&E-approved test plan precluded its use in an operational evaluation. In particular, problems observed with the ship's tactical radar modes caused the crew to shift to a non-operationally representative radar mode for the duration of the test. Determining how those radar problems potentially degrade operational performance is critical for DOT&E to assess the effectiveness of the SUW Increment 3 MP on the *Independence* variant. Consequently, the ability of the ship's radar to support missile engagements was not assessed.
- While the Navy did not conduct the lethality assessment of the SSMM against all of the FIAC surrogate targets, as outlined in the DOT&E-approved Live Fire Strategy, testing and M&S supported the conclusion that SSMM can be lethal against a spectrum of small boat threats in more benign engagement conditions (e.g., smaller swarm size, lower speed).

ASW

- DOT&E has no operational test data and cannot assess system performance. However, system reliability is a concern due to the observed failures throughout DT and the limited opportunity for reliability growth before operational evaluation.
- The lack of an LWT degrades the capability of the LCS with ASW MP to defeat an incoming torpedo. DOT&E has no data to quantify this degradation; however, the LCS with ASW MP will operate with greater wartime risk until the LWT is available.

MCM MP

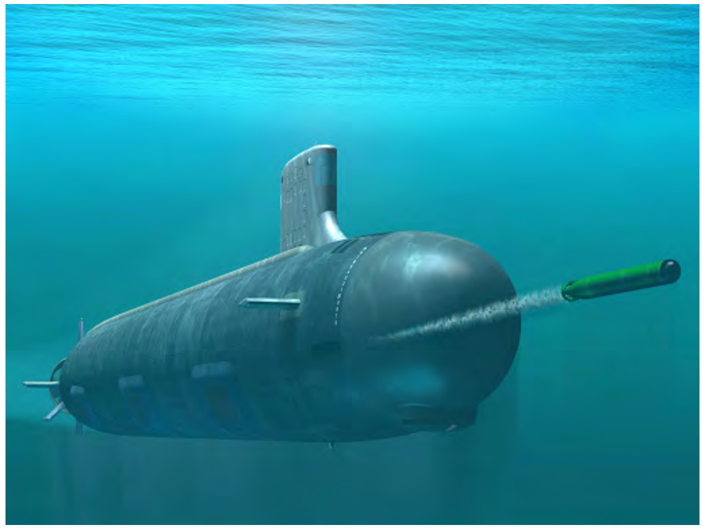
- See the UISS Annual Report on page 169 for complete details.
- DOT&E has no data at this time to assess the integration of the UISS and Knifefish Components on the *Independence* variant.

Recommendations

The Navy should:

1. Fund and conduct end-to-end mission operational testing of the LCS *Independence* variant with SUW Increment 3 MP, to include resourcing the threat target surrogates required for operational testing.
2. Resource and conduct the air warfare test events against anti-ship cruise missile surrogates planned as part of the DOT&E-approved Capstone Enterprise Air Warfare Ship Self-Defense TEMP and LCS TEMP.
3. Resource the development of the LCS PRA combat system M&S suite.
4. Use the LCS Advanced Mine Simulator System (AMISS) trial data to determine the root cause of discrepancies between the trial results and the Total Mine Simulation System (TMSS) predictions (e.g., sensitivity to threat, environmental, and ship variables).
5. Fund the development and delivery of the LWT as soon as feasible to minimize risk to the LCS with ASW MP from incoming torpedoes.
6. Proceed with the planning and resourcing of the cybersecurity testing of the seaframes with the three MPs installed.

MK 48 Torpedo Modifications



Executive Summary

- The Navy collected performance data on the Advanced Processor Build 5 (APB 5) MK 48 torpedo from 115 torpedo firings against real-world submarine and surface ship targets. The Navy intends to complete IOT&E in 2QFY21. DOT&E will submit an IOT&E report after the Navy has completed testing.
- The Navy also collected APB 5 performance data using the Environment Centric Weapons Analysis Facility (ECWAF) that stimulates an in-the-loop APB 5 torpedo within a modeled environment. Successful development of the ECWAF for use against both submarines and surface ships will reduce at-sea torpedo runs for the next MK 48 variant, APB 6, by approximately 50 percent.

System

- The MK 48 torpedo is the only anti-submarine and anti-surface ship weapon used by U.S. submarines.
- Fielded MK 48 torpedo variants include MK 48 Mod 6, Mod 6 Advanced Common Torpedo (ACOT), and Mod 7 Common Broadband Advanced Sonar System (CBASS).
- Torpedo improvements are made within CBASS variants as a shared development effort with the Royal Australian Navy. Torpedo improvements are primarily software based and the torpedo is commonly referred to by its software build (e.g., APB 5 torpedo).

Mission

The Submarine Force employs the MK 48 torpedo to destroy submarines and surface ships in all ocean environments.

Major Contractor

Lockheed Martin Sippican Inc. – Marion, Massachusetts

Activity

- From September 2019 through June 2020, the Navy collected APB 5 performance data from simulation runs against modeled submarine targets using the ECWAF at the Naval Undersea Warfare Command in Newport, Rhode Island. The ECWAF stimulates an in-the-loop APB 5 torpedo within a modeled environment.
- In October 2019, the Navy concluded that the APB 5 torpedo was ready for operational testing against surface ships. The Navy had previously concluded that the APB 5 torpedo was ready for operational testing against submarines in August 2018.
- In November 2019 through September 2020, the Navy collected APB 5 performance data on 115 exercise torpedo firings against submarines and surface ships. The Navy conducted the following events in accordance with DOT&E-approved test plans:
  - One hundred and two torpedo firings during fleet training events (Submarine Command Courses and Combat Readiness Evaluations).
  - Thirteen APB 5 torpedo firings in a dedicated in-water operational test event to the North of Maui, Hawaii.
- In November 2019, the Navy commenced validation of the ECWAF for APB 5 performance data collection against modeled submarines and environments. Validation compares in-water exercise torpedo performance to that demonstrated with simulation. The Navy prioritized development and validation of the ECWAF for use in assessing APB 5 performance against submarines. The Navy deferred development and validation of the ECWAF for use against modeled surface ships until the operational testing of the next variant, APB 6, of the MK 48 torpedo.

Assessment

- DOT&E will report operational effectiveness and suitability after the completion of IOT&E; the Navy intends to complete IOT&E of the APB 5 torpedo in 2QFY21. DOT&E impressions of initial performance were reported in a classified Early Fielding Report dated September 23, 2019.
- ECWAF runs contribute to the APB 5 evaluation by providing supplemental performance data for the at-sea scenarios and performance data against threat submarines in environments

that are unavailable for at-sea testing. The Navy expects to complete the accreditation of the ECWAF for evaluation of APB 5 performance against submarines in 1QFY21.

- Accreditation of the ECWAF to support performance assessment against both submarines and surface ships will reduce at-sea testing of the next variant, APB 6, by approximately 50 percent. The Navy appropriately focused ECWAF development on modeling and simulation related to submarines for APB 5. However, the Navy must complete development of the models for surface ships in order to achieve the full reduction in at-sea testing for APB 6.

Recommendation

1. The Navy should complete development of models related to surface ships in the ECWAF as soon as feasible to support the operational assessment of the APB 6 torpedo.

MK 54 Lightweight Torpedo Upgrades Including: High Altitude Anti-Submarine Warfare (ASW) Weapon Capability (HAAWC)

Executive Summary

- The Navy conducted a combined test event for the MK 54 Mod 1 lightweight torpedo and High Altitude Anti-Submarine Warfare (ASW) Weapon Capability (HAAWC). The Navy completed 13 HAAWC deployments that mutually supported MK 54 Mod 1 test objectives. Combining these two test events saved the Navy approximately $6.2 Million in test resources.
- The Navy intends to complete the IOT&Es for MK 54 Mod 1 and HAAWC in FY21. DOT&E will submit IOT&E reports after testing is completed for each system.

System

MK 54 Lightweight Torpedo

- The MK 54 lightweight torpedo is the most capable ASW weapon used by U.S. surface ships, fixed-wing aircraft, and helicopters.
- The Navy delivers incremental improvements of the MK 54 that include hardware and software modifications:
  - The MK 54 Mod 1 is in test. The MK 54 Mod 1 includes a new sonar array that provides higher resolution than previous MK 54 variants. Software modifications exploit the additional capability provided by the new sonar array. The MK 54 Mod 1 uses Advanced Processor Build (APB) 5 software that shares many components with the APB 5 variant of the MK 48 heavyweight torpedo. The MK 54 Mod 1 torpedo is not approved for the Vertical Launched Anti-submarine rocket (VLA).
  - The MK 54 Mod 2 is expected to deliver an Early Operational Capability in FY26. The MK 54 Mod 2 will have a new propulsion system and warhead. The MK 54 Mod 2 is not compatible with the current VLA or HAAWC systems.
- The current MK 54 Mod 0 and MK 54 Mod 0 Block Upgrade variants support the VLA.

HAAWC

- HAAWC provides an adapter wing-kit that allows aircrews to deploy a MK 54 from a P-8A Multi-mission Maritime Aircraft from higher than traditional altitudes. The wing-kit glides the MK 54 to a water entry point directed by the P-8A combat system.

Mission

Commanders employ naval surface ships and aircraft equipped with the MK 54 torpedo to conduct ASW:

- For offensive purposes, when deployed by surface ships with VLA capability, ASW aircraft, and ASW helicopters
- For defensive purposes, when deployed by surface ships with surface vessel torpedo tubes capability

Major Contractors

- Raytheon Integrated Defense Systems – Tewksbury, Massachusetts
- Progeny Systems Corporation – Manassas, Virginia
- Boeing Company – St. Charles, Missouri

Activity

MK 54 Mod 1

- In December 2019, the Navy concluded that the MK 54 Mod 1 torpedo was ready for operational testing.
- The Navy collected MK 54 Mod 1 torpedo performance data from 18 exercise torpedo firings. The Navy conducted the following events in accordance with DOT&E-approved test plans:
  - In December 2019, the Navy conducted a dedicated operational test event at the Jacksonville Shallow Water Test Range off the coast of Florida. However, the

submarine providing target support received higher priority tasking early in event execution; therefore, the Navy only obtained data from 1 of 21 planned torpedo firings.
  - In May 2020, the Navy demonstrated capability to launch the MK 54 Mod 1 from a surface vessel torpedo tube with one torpedo firing.
  - In September 2020, the Navy conducted a combined test event for evaluation of MK 54 Mod 1 and HAAWC at the Pacific Missile Range Facility in Hawaii. Thirteen torpedoes used HAAWC and 3 torpedoes used traditional aircraft release against a submarine to support all MK 54 Mod 1 assessment objectives. The Navy deferred the event from its originally planned April 2020 execution due to the coronavirus (COVID-19) pandemic. Deferral of this test event caused a follow-on test event for MK 54 Mod 1 to shift from FY20 to FY21.
- The Navy intends to complete IOT&E in FY21.

HAAWC

- In August 2020, the Navy concluded that HAAWC was ready for operational testing.
- The Navy collected HAAWC flight performance data on 17 HAAWC firings. The Navy conducted the following events in accordance with DOT&E-approved test plans:
  - From January through February 2020, the Navy deployed two HAAWCs with MK 54 surrogates (weight and shape of an MK 54) for placement accuracy data.
  - In September 2020, the Navy conducted 15 HAAWC deployments during the previously identified combined test event with MK 54 Mod 1.
    - Thirteen HAAWC deployments successfully released a MK 54 Mod 1 torpedo and will support both HAAWC flight and MK 54 Mod 1 torpedo performance data.
    - Two HAAWC deployments with MK 54 Mod 1 torpedoes experienced flight failures and did not successfully release the torpedo; these deployments provide HAAWC reliability data only.
- The Navy intends to complete HAAWC IOT&E in FY21.

Assessment

MK 54 Mod 1

- DOT&E has insufficient data to make a preliminary assessment on the MK 54 Mod 1 torpedo capability to search and acquire threat submarines. DOT&E will submit a classified IOT&E report for MK 54 Mod 1 after completion of testing.
- The combined test event for MK 54 Mod 1 and HAAWC was an effective and efficient use of test resources. The Navy conducted 13 HAAWC deployments against a submarine to support the objectives of each test program. The combined test event saved the Navy approximately $6.2 Million in test resources.

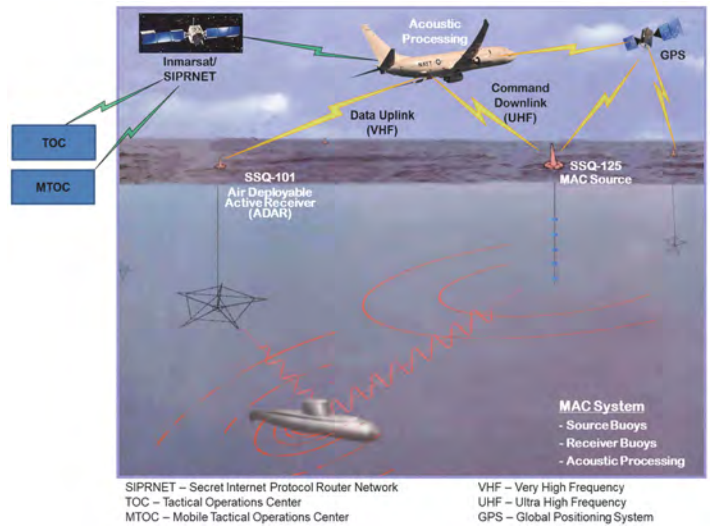
HAAWC

- Analysis of HAAWC firing data is in progress. DOT&E cannot make a preliminary assessment of operational effectiveness and suitability; however, HAAWC capability to deliver its torpedo payload is likely to meet its accuracy requirement based on data collected from 2019 and early 2020.
- DOT&E will submit a classified IOT&E report for HAAWC after the completion of testing.

Recommendation

1. The Navy should determine and correct the root causes of the two HAAWC flight failures as soon as feasible.

Multistatic Active Coherent (MAC) System



Executive Summary

- In FY19, DOT&E and the Navy agreed to end the FOT&E of the submarine search capability provided by the Engineering Change Proposal (ECP) 2 and ECP 4 upgrades to the P-8A Poseidon Multi-Mission Aircraft using the Multistatic Active Coherent (MAC) Phase 1 system. The Navy completed 11 of 32 planned FOT&E flights in accordance with DOT&E-approved test plans. To augment the analysis, DOT&E used data collected by fleet squadrons during anti-submarine warfare (ASW) exercises and operations conducted from FY15-19.
- FOT&E and fleet data were adequate to assess the operational effectiveness and suitability of the improved P-8A ASW capability. Cybersecurity FOT&E, completed in FY17, was adequate to assess the ECP 2 P-8A's ability to sustain MAC ASW missions in a cyber-contested environment.
- DOT&E issued an FOT&E report on the ECP 2 and ECP 4 P-8A equipped with the MAC Phase 1 system in September 2020.
  - FOT&E demonstrated that operator decision aids improved operator detection performance in some environments.
  - The MAC system continues to provide an effective wide-area ASW search capability in some operational environments, but it does not meet program requirements for all test environments.
  - Cybersecurity testing of the P-8A aircraft (only conducted with ECP 2 upgrades) identified high priority areas for improvement.

System

- The MAC system is an active sonar system composed of two types of sonobuoys: source (i.e., transmitter) (AN/SSQ-125) sonobouy, and receiver (AN/SSQ-101) sonobuoy, and an acoustic processing and aircraft mission computer software suite. It is employed by the Navy's maritime patrol aircraft (P-3Cs and P-8As) to search for and locate threat submarines in a variety of ocean conditions.
- The MAC sensor system is the latest version of the Navy's Active Extended Echo Ranging (EER) airborne wide-area ASW active sonar search systems. To improve ASW search performance in shallow water and open ocean, the MAC system uses the new coherent source (AN/SSQ-125) sonobuoy that enables multiple pings, optimized waveforms, and various ping durations, none of which were available in the legacy Improved EER (IEER) system.
- Since fielding the MAC Phase 1 system in 2015, the Navy has enhanced the MAC software to improve operator analysis tools and improved the MAC sonobuoys (source and receiver). The Navy continues to develop the MAC Phase 2 system to improve the capability in a wider variety of acoustic ocean environments in order to span the operational envelope of threat submarine operations.
- To plan MAC missions, the Navy updated the Active System Performance Estimate Computer Tool (ASPECT)/Multistatic Planning Acoustics Toolkit previously used to plan IEER system missions.
- MAC is the primary wide-area acoustic search system for the P-8A aircraft.
- ECP 2 upgrade consisted of operator decision aid tools to the MAC system, and ECP 4 further improved these tools.

Mission

P-8A crews equipped with MAC perform the search, detection, and localization phases of the ASW mission. MAC is particularly focused on large-area active acoustic searches for threat submarines.

Major Contractors

- Boeing Defense, Space, and Security – St. Louis, Missouri
  - Boeing Huntington Beach, California
  - Boeing Kent, Washington
- Lockheed Martin – Manassas, Virginia
- Sparton Electronics Florida, Inc. – De Leon Springs, Florida
- Ultra Electronics, Undersea Sensor Systems Incorporated (USSI) – Columbia City, Indiana

Activity

- In September 2020, DOT&E issued a classified FOT&E report for MAC Phase 1 integrated on P-8A aircraft with ECP 2 and ECP 4 upgrades. DOT&E augmented its analysis of MAC FOT&E results with data collected by fleet squadrons during anti-submarine warfare (ASW) exercises and operations conducted from FY15-19.
- The Navy is developing the MAC Phase 2 system to improve submarine detection and wide-area ASW search performance and is upgrading the P-8A network architecture.

Assessment

- The MAC Phase 1 system continues to provide an effective wide-area ASW search capability in some operational environments. However, the system does not meet program requirements in all test environments. P-8A operator decision aids, which the Navy introduced with ECP 2 and ECP 4 upgrades improved operator detection performance in some environments. Additional information is detailed in the classified September 2020 DOT&E FOT&E report on the MAC Phase 1 system.
- The MAC system remains operationally suitable when installed on the P-8A Poseidon aircraft with ECP 2 and ECP 4 upgrades. Operational reliability and availability of the MAC source sonobuoy met Navy requirements during FOT&E, but MAC source sonobuoy reliability was slightly less than the Navy requirement during fleet exercises and operations.
- Cybersecurity testing of the P-8A aircraft (only conducted with ECP 2 upgrades) identified high-priority areas for improvement. The September 2020 DOT&E MAC FOT&E report includes specific test results and recommendations.

Recommendation

1. The Navy should continue efforts to address the recommendations in DOT&E's classified FOT&E report associated with the P-8A aircraft, mission systems, and MAC Phase 1 system.

Next Generation Jammer

Executive Summary

- The Next Generation Jammer (NGJ) – Mid-Band (MB) Milestone C decision planned for September 2020 has been rescheduled to January 2021. Challenges due to late pod deliveries, the complexity of test equipment integration, initial manufacturing and quality issues, and the manpower and efficiency effects of the global coronavirus (COVID-19) pandemic have affected planned execution. The program is still on track to meet the March 2021 threshold for Milestone C.
- Early testing conducted in anechoic chambers has not yet verified that the NGJ-MB meets system-level radiated power requirements in every frequency region. Updated array calibration that improves radiated power has been tested at the subsystem level. System-level validation of radiated power is scheduled for later this year in the anechoic chamber.
- Delays to the NGJ-MB program have shifted the first phase of the Navy's Capabilities Based Test and Evaluation (CBT&E) phase to Naval Air Station (NAS) Patuxent River, Maryland, from NAS China Lake, California.
- The NGJ – Low Band (LB) program completed two Demonstration of Existing Technologies (DET) contracts on August 31, 2020, to determine technical maturity of required technology to field the NGJ-LB capabilities.

System

- The NGJ is being acquired in three separate acquisition programs: Increment 1 (MB), Increment 2 (LB), and Increment 3 (High-Band (HB)). These will eventually replace all of the legacy ALQ-99 Tactical Jammer System pods that have been developed and fielded since 1971 on the EA-6B and are currently flown on the EA-18G.
- The Navy is in the process of selecting NGJ-LB designs prior to its Milestone B scheduled in early FY21. The HB program is still very early in the acquisition and no proposed designs have been selected for review.
- The NGJ, and the ALQ-99 pods it is replacing, are used to conduct Airborne Electronic Attack (AEA) against Integrated Air Defense Systems. The NGJ-MB consists of a pair of pods that will be deployed on the EA-18G aircraft that work with the ALQ-218 receiver system and off-board assets. The NGJ-MB will be added to the EA-18G as part of its H16 Software Configuration Set Block Upgrade.
- The NGJ-MB is intended to engage multiple advanced threats at greater standoff ranges than the ALQ-99. It accomplishes this with greater Effective Isotropic Radiated Power (EIRP) and four active electronically scanned arrays.

Mission

- EA-18Gs equipped with NGJ will act as a component of future carrier air wings and expeditionary forces, providing AEA capabilities against a wider variety of radio frequency (RF) targets. The NGJ is designed to improve EA-18G capability against modern, advanced RF threats; communications; datalinks; and non-traditional RF targets.
- The Navy will use the NGJ to deny, degrade, or deceive the enemy's use of the electromagnetic spectrum, employing both reactive and pre-emptive jamming techniques while enhancing the friendly force's use of the electromagnetic spectrum.
- The Navy has four electronic attack mission profiles: standoff, modified escort, penetrating escort, and stand-in. The NGJ-MB will primarily fly the standoff and modified escort profiles.

Major Contractors

- For the NGJ-MB:
  - Raytheon Intelligence and Space – El Segundo, California
  - The Boeing Company, Integrated Defense Systems – St. Louis, Missouri
- The NGJ-LB is still involved in a design selection process, with results expected later this calendar year.

Activity

- COVID-19 delayed several NGJ-MB test events. The Navy reduced the number of personnel allowed access to test facilities in response to the pandemic. Additionally, other entities responsible for producing and shipping system components needed for testing were hindered by the pandemic, adversely affecting the NGJ-MB's timeline.

- The Navy was originally scheduled to decide if the program was ready to proceed past Milestone C in September 2020. Program delays prevented the completion of the 10 development test flights required by the acquisition decision memorandum (ADM) to enter Milestone C. Delays were caused by a number of factors in addition to COVID-19, including late pod deliveries, complexity of test equipment integration, and initial manufacturing and quality issues discovered with the flight test deliveries. In response to these delays and to allow the program the time it needs to address entrance criteria, the Milestone C decision has been scheduled in January 2021, 2 months ahead of the threshold date of March 2021.
- Preliminary NGJ-MB chamber testing began at the end of 2019 and continued until summer 2020, taking place mostly at the Air Combat Environment Test and Evaluation Facility (ACETEF) and the High-power Electronic Attack Technique Radiation (HEATR) Chamber. In addition to the significant effort required to integrate the NGJ-MB pods to operate in the facilities, other tests completed include Hazard of Electromagnetic Radiation to Personnel, along with pod functionality and performance tests. Functionality demonstrated includes making jammer assignments with full, half, and quarter arrays; timing and beam commutation between assignments; and radiation from 2 full arrays.
- The Navy completed the chamber portion of the electromagnetic environmental effects (E3) testing, in support of airworthiness certification of the NGJ-MB in early summer 2020, and began the flight portions of the E3 testing in September 2020.
- The Navy began executing trial developmental runs for NGJ-MB in the ACETEF along with its jammer technique generation testing in the HEATR chamber, in August 2020. Developmental design of experiment runs for score are scheduled to begin in November 2020. The Navy plans to complete a representative set of jammer technique test points in the HEATR lab to support Milestone C, as well as preliminary EIRP testing in the ACETEF chamber.
- The Navy is in the process of verifying the tools planned for the modeling and simulation-based analysis of the NGJ-MB. Classification issues have so far prevented the program's receipt of the necessary EA-18G open air range reference data and delayed the start of tool validation.
- The Navy has not yet conducted operational testing on the NGJ-MB. Due to the delays described above, the operational test runs identified in the DOT&E-approved test plan have been rescheduled to occur at NAS Patuxent River, Maryland.
- In August 2020, the Navy concluded two DET contracts, one with Northrup Grumman Corporation and one with L3Harris, for the NGJ-LB program. The DET phase consisted of an assessment of industry technical maturity.

Assessment

- More time and implementation of an updated array calibration process is required to assess system-level radiated power requirements. Early testing conducted in anechoic chambers has not yet verified that the NGJ-MB meets system-level radiated power requirements in every frequency region. The NGJ-MB program is implementing an updated array calibration process that improves radiated power across the array spectrum. This fix has been tested at the subsystem level with positive results and is scheduled to be verified with the entire system in the chamber this December.
- The Navy may have a solution to the design problem preventing the NGJ-MB's Ram Air Turbine Generator (RATG) from safely rotating at full speed. A redesigned RATG will be implemented in the delivery of the System Demonstration Test Articles (SDTA) in 2021 to support the completion of developmental and operational testing and demonstrate full power operation in flight.
- Late NGJ-MB pod deliveries, manufacturing and quality issues, and test integration challenges have resulted in the first CBT&E period to be rescheduled and moved to occur at NAS Patuxent River, Maryland. Moving the test could lead to delays or even the elimination of some of the operationally representative test events prior to Milestone C.
- The Navy originally planned to have at least 160 hours of flight time with the NGJ-MB from which it would calculate an early mean flight hours before operational mission failure value. The Navy will be unable to log that many flight hours with the system prior to the Milestone C decision if it only flies the E3 test flights and the 10 required developmental test flights.
- Adequate ranges with advanced adversary integrated air defense systems will not be completed until calendar year 2022.

Recommendations

The Navy should:

1. Complete all planned NGJ-MB chamber test points required by the ADM and the 10 required developmental test flights to inform the Milestone C decision.
2. Revise the current CBT&E implementation strategy to explore test mechanisms that mitigate the effects of NGJ-MB program delays and ensure that necessary operationally relevant testing will be conducted prior to IOT&E.
3. Establish a CBT&E working group within the Integrated Test Team for the NGJ–LB (Increment 2) program that is similar to the NGJ-MB program.
4. Verify the performance of the NGJ-MB arrays with the updated calibration technique in the chamber, continue the development program, and test for score to verify radiated power requirements are being met.
5. Ensure the NGJ-MB is tested at open air ranges against the most advanced threats, and utilize CBT&E to increase collaboration between Mission Engineering and Live Virtual Constructive distributed test environments to focus the limited live test resources on critical operational factors.

Offensive Anti-Surface Warfare (OASuW) Increment 1

Executive Summary

- DOT&E released a classified report for the Quick Reaction Assessment (QRA) of the Offensive Anti-Surface Warfare (OASuW) Increment 1 program, also referenced as the Long Range Anti-Ship Missile (LRASM) 1.0 program, in 2QFY20, covering FY17-19 LRASM integrated testing. DOT&E recommended the Navy conduct IOT&E on the final LRASM configuration (1.1) to stress the system by using the full set of expected operational conditions.
- The OASuW Increment 1 program continues development improvements of missile hardware and software to enhance targeting capabilities as an incremental upgrade, LRASM 1.1.

System

- The OASuW Increment 1 program is the first weapon of an incremental approach to produce an OASuW capability in response to a U.S. Pacific Fleet Urgent Operational Need generated in 2008.
- The OASuW Increment 1 is an accelerated acquisition program to procure a limited number of air-launched missiles to meet this near-term U.S. Pacific Fleet requirement by leveraging the Defense Advanced Research Projects Agency LRASM.
- LRASM, the weapon system for the OASuW Increment 1, is a long-range, conventional, air-to-surface, precision standoff weapon. The Navy's F/A-18E/F or the Air Force's B-1B aircraft can launch LRASM.
- LRASM, designated as the AGM-158C, is derived from the Joint Air-to-Surface Standoff Missile Extended Range (JASSM ER). An anti-jam GPS guidance system, radio frequency sensor (RFS), and an infrared sensor support guidance and targeting.
- Once launched, LRASM guides to an initial point and employs onboard sensors to locate, identify, and provide terminal guidance to the target.
- OASuW Increment 2 will deliver long-term anti-surface warfare (ASuW) capabilities to counter future threats. The DOD continues to plan for OASuW Increment 2 to be developed via full and open competition, and Initial Operational Capability is anticipated FY28-30. Due to congressional budget reductions for OASuW Increment 2, the Navy funded an incremental upgrade – LRASM 1.1 – to bridge the gap until an OASuW Increment 2 program of record is established. This upgrade incorporates missile hardware and software improvements to address component obsolescence issues and enhance targeting capabilities.

Mission

Combatant Commanders will use units equipped with LRASM to destroy ships from standoff ranges.

Major Contractor

Lockheed Martin Missiles and Fire Control – Orlando, Florida

Activity

- An Early Operational Capability (EOC) for LRASM 1.0 was fielded for the Air Force B-1B in December 2018 and the Navy F/A-18E/F in November 2019.
- DOT&E published a classified QRA report in 2QFY20 covering FY17-19 LRASM 1.0 integrated testing.
- FY20 component-level testing of LRASM 1.0 continued development of missile hardware and software to enhance targeting capabilities of LRASM 1.1.
- The Navy conducted a LRASM 1.1 cybersecurity table top exercise in January 2020. DOT&E approved a Master Test Strategy (MTS) for LRASM 1.1 on January 30, 2020. This included an independent operational test period consistent with the number of assets planned for purchase. LRASM 1.1 integrated testing and a subsequent QRA are planned for FY21-22. DOT&E will release a classified report once testing is complete.
- The Navy conducted a live firing of a LRASM 1.0 during Valiant Shield in September 2020.

Assessment

- Based on the FY17-19 LRASM 1.0 integrated testing, DOT&E assessed the following:

- The LRASM 1.0 QRA had limited operational realism.
- Multiple hardware and software failures occurred in the QRA program that the Navy continues to address.
- The Navy should conduct an IOT&E on LRASM 1.1, stressing the system by using the full set of expected operational conditions.

• Accreditation of the modeling and simulation (M&S) environment to fully assess LRASM operational performance is incomplete due to limitations presented by the live Integrated Test Event environment. An accurate M&S environment is required to determine whether the system will meet key performance parameter requirements and demonstrate mission capability in operationally realistic environments. Further details are classified.

Recommendations

The Navy should:

1. Conduct IOT&E on the final LRASM configuration (1.1), stressing the system by using the full set of expected operational conditions.
2. Complete the development and validation of the M&S environment to facilitate the operational effectiveness evaluation.

Over-The-Horizon Weapon System (OTH-WS)

Executive Summary

- In FY20, DOT&E issued an Early Fielding Report (EFR) on the Navy's Quick Reaction Assessment (QRA) of the Over-The-Horizon Weapons System (OTH-WS). Due to the limited scope of the test, DOT&E did not assess effectiveness, lethality, or suitability in this report.
- The Navy plans to conduct IOT&E and LFT&E in FY21 and is developing a Test and Evaluation Master Plan (TEMP) and a Live Fire Test and Evaluation Strategy to support those test events.

System

- The OTH-WS program is a long-range, surface-to-surface warfare system intended to engage maritime targets both inside and beyond the radar horizon. The system consists of an operator interface console, Naval Strike Missile (NSM), and the Missile Launching System.
- The NSM is an offensive missile with an imaging infrared seeker and utilizes a semi-armor-piercing warhead optimized for anti-surface warfare.
- The OTH-WS is a stand-alone system requiring minimal integration into the host platform. The OTH-WS will receive targeting data via tactical communications from combatant platforms or airborne sensors and requires no guidance after launch. The Navy intends to integrate the OTH-WS on the Littoral Combat Ship (LCS) variants; guided-missile frigate, FFG(X); and amphibious LPD-class ships. The Marine Corps is also acquiring the NSM to install on the Navy/Marine Expeditionary Ship Interdiction System, which places an NSM launcher on an unmanned Joint Light Tactical Vehicle (JLTV)-based mobile launch platform.

Mission

The Joint Force Commander/Strike Group Commander employs OTH-WS-equipped platforms to conduct offensive over-the-horizon and within-the-horizon engagements against maritime targets.

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- DOT&E approved the OTH-WS OT&E plan in June 2020.
- DOT&E issued an EFR in February 2020 based on the QRA conducted in July 2019. This report assessed the integration and safety of the system to support early deployment on the *Independence*-variant LCS as well as the cybersecurity posture.
- The Marine Corps planned a live firing of an NSM from a JLTV-based mobile launch platform in June 2020, but postponed the event after discovering a software misconfiguration on the missile. The Marine Corps intends to conduct this live fire event in November 2020. This test event supports the overall OTH-WS IOT&E evaluation and is in accordance with the DOT&E-approved test plan.
- The TEMP and LFT&E Strategy are under development. The final scope of the OT/LFT&E programs are contingent upon the adequacy and availability of missile performance data collected by the foreign supplier during the missile's initial development.
- In 2020, the Navy reprioritized OTH-WS T&E funds, and was therefore unable to resource or schedule LFT&E testing.
- The Navy intends to conduct lethality testing to determine blast, penetration, and fragmentation characteristics of the warhead. In coordination with DOT&E, the Navy completed the verification and validation (V&V) plan for the Advanced Survivability Assessment Program (ASAP), which the Navy will use to conduct the OTH-WS lethality assessment of a range of representative maritime targets.

Assessment

- As reported in the EFR, the QRA did not conduct any live end-to-end flight testing. Due to the limited scope of the QRA, DOT&E did not assess effectiveness, lethality, or suitability in the report.
- DOT&E assessed the 2019 Cyber Survivability Table Top event in the classified OTH-WS EFR.

- Reprioritization of the intended OTH-WS T&E budget has resulted in risk to the execution of the LFT&E program.

Recommendations

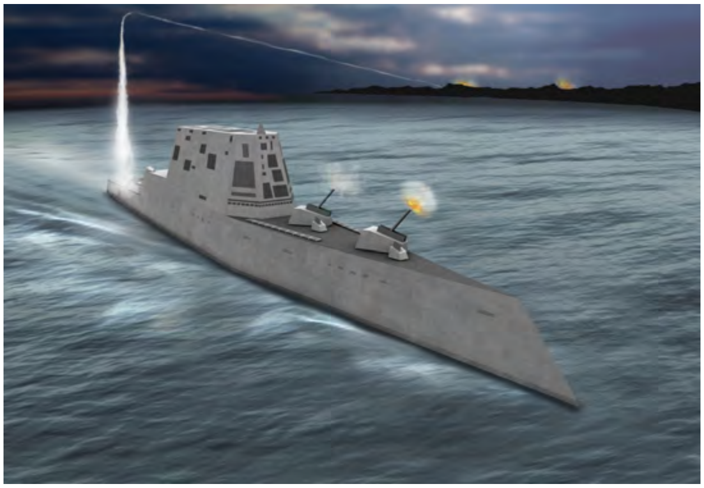
The Navy should:

1. Address the recommendations contained within the classified DOT&E OTH-WS EFR.
2. Allocate the resources for an adequate and timely execution of the proposed LFT&E Strategy.

Ship Self Defense for DDG 1000

Executive Summary

- The USS *Zumwalt* (DDG 1000) shipboard air defense combat system is currently undergoing testing on the Self-Defense Test Ship. Testing has been delayed due to problems discovered with the combat system.
- Additional delays may occur if the Navy removes SPY-3, intended to be installed onboard DDG 1002, from the test ship prior to executing the one remaining planned test event.
- The Navy no longer plans to execute five events on the Self-Defense Test Ship due to schedule delays, prior test performance, or unacceptably low performance predictions.



System

The DDG 1000 ship self-defense combat system, *Zumwalt* Combat System (ZCS), consists of several programs:

- Total Ship Computing Environment (TSCE) – The command and control architecture unique to ZCS.
- Multi-Function Radar (MFR/SPY-3) – The new X-band radar going on DDG 1000-class guided-missile destroyers and the USS *Gerald R. Ford* (CVN 78).
- AN/USG-2B Cooperative Engagement Capability (CEC) – The tracker and sensor data fusion and distribution system.
- Surface Electronic Warfare Improvement Program (SEWIP) Block 2 (SLQ-32A(V)6) – The passive electronic sensor used to detect and identify hostile radars and missiles.
- Evolved Sea Sparrow Missile (ESSM) Block 1 with Joint Universal Weapon Link (JUWL) – The short-range missile interceptor used to defeat air threats at close-in ranges, and the system used for radar-missile communication and support. Within the U.S. Navy, only the DDG 1000-class ships and the USS *Gerald R. Ford* (CVN 78) use the ESSM with JUWL.
- Standard Missile 2 (SM-2 Block IIIAZ) with JUWL – The unique ZCS variant of SM-2 used to defeat air threats at longer ranges.
- MK 57 Vertical Launch System (VLS) – The DDG 1000-only vertical missile launcher variant.

Mission

Commanders use the DDG 1000 self-defense systems (TSCE, SPY-3, CEC, SEWIP Block 2, ESSM and SM-2 with JUWL, and VLS) to protect the ship and its sailors from enemy air threats in both clear and jammed environments.

Major Contractors

- TSCE and SPY-3: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts
- ESSM and SM-2 with JUWL, VLS: Raytheon Missile Systems – Tucson, Arizona
- SEWIP Block 2: Lockheed Martin – Syracuse, New York
- CEC: Raytheon Company, Integrated Defense Systems – St. Petersburg, Florida

Activity

- In FY20, the Navy conducted one developmental test on the Self-Defense Test Ship. To date, the Navy has conducted 5 of the 10 DDG 1000 tests planned for the Self-Defense Test Ship (4 of 6 developmental tests, and 1 of 4 integrated tests) and has canceled the remaining 3 integrated tests and 2 developmental tests because of schedule delays, prior test performance, or unacceptably low performance predictions.
- All tests have been conducted in accordance with the DOT&E-approved test plan.
- The Navy intends to repeat a previously executed integrated test in December 2020.
- To address problems discovered during this phase of integrated testing, the Navy executed three engineering tests and two tracking exercises aboard the Self-Defense Test Ship.
- The DDG 1000 Probability of Raid Annihilation (PRA) modeling and simulation testbed has been a critical portion of developmental testing and risk reduction. It is still undergoing development and finalization prior to the operational test runs for record (planned for 2022).
- Lead ship developmental testing continued with four tracking exercises conducted in 2019 and 2020. An SM-2 Block IIIAZ

developmental testing missile firing was conducted on October 14, 2020.

Assessment

- Several problems have been uncovered during the DDG 1000 Self-Defense Test Ship events. In particular, issues with radar-to-missile support put the test program on hold until the root cause of the problem(s) is identified and the corrections are implemented.
- The DDG 1000 self-defense test program will not be adequate if all remaining Self-Defense Test Ship events are not completed. If these events are not completed, those resources should be allocated to execute air defense scenarios on the USS *Zumwalt*.
- The remaining planned test event is at risk of not occurring for several reasons:
    - The Navy is considering removing the SPY-3 radar on the Self-Defense Test Ship for installation on DDG 1002.
    - Determining the root cause of and correcting problems found in developmental and early integrated testing has repeatedly delayed event execution.
    - Several other test programs are competing for aerial target resources, Self-Defense Test Ship time, and range time.

Recommendations

The Navy should:

1. Develop a schedule, funding, and execution strategy for completing the DDG 1000 self-defense assessment on the Self Defense Test Ship.
2. Consider carrying over resources not used for the DDG 1000 Self-Defense Test Ship events to execute air defense scenarios aboard USS *Zumwalt*.
3. Continue to develop and improve the DDG 1000 PRA Testbed, in particular its missile, radar, and electronic warfare models.

Standard Missile (SM)-6

Executive Summary
- The Navy completed modeling and simulation (M&S) runs for the record of Standard Missile (SM)-6 Block (BLK) IA. DOT&E will publish the SM-6 BLK IA FOT&E report in 1QFY21.
- The Navy is leveraging inherent capabilities in the SM-6 missile to evolve the overall SM-6 mission set. The Navy's SM-6 Future Capabilities Demonstration (FCD) project executes these mission expansions under the overall management of the SM-6 program.

System
- SM-6 BLK I and BLK IA are the latest evolution of the Standard Missile family of fleet air defense missiles.
- The Navy employs the SM-6 from Aegis-equipped cruisers and destroyers (i.e., *Ticonderoga*-class cruisers and *Arleigh Burke*-class destroyers).
- The SM-6 seeker and terminal guidance electronics derive from technology developed in the Advanced Medium-Range Air-to-Air Missile program.
- SM-6 retains the legacy SM semi-active radar homing capability.
- SM-6 receives midcourse flight control from the Aegis Weapon System (AWS) via the ship's radar; terminal flight control is autonomous via the missile's active seeker or supported by the AWS via the ship's illuminator.
- The Navy intends for SM-6 BLK IA to provide improved performance against advanced threats.
- SM-6 Dual I capability is fielded and provides Sea-Based Terminal Ballistic Missile Defense capability against short-range ballistic missiles.
- The Navy is expanding the SM-6 mission areas via the FCD project.

Mission
- The Joint Force Commander/Strike Group Commander may employ naval units equipped with the SM-6:
  - For air defense against fixed-/rotary-winged targets and anti-ship missiles operating at altitudes ranging from very high to sea-skimming.
  - To provide extended-range capability against surface targets as part of the FCD.
  - To provide extended range over-the-horizon capability against at-sea and overland threats as part of the Navy Integrated Fire Control – Counter Air From the Sea operational concept.
- The Joint Force Commander/Strike Group Commander will use SM-6 Dual I to provide Sea-Based Terminal capability against short- and medium-range ballistic missiles in their terminal phase of flight, against anti-ship cruise missiles, and against all types of aircraft.

Major Contractor
Raytheon Missile Systems – Tucson, Arizona

Activity
- The Navy completed M&S runs for the record for SM-6 BLK IA in FY20 in accordance with the DOT&E-approved test plans.
- DOT&E completed its assessment and evaluation of the SM-6 BLK IA FOT&E. DOT&E will publish its report in 1QFY21.
- In 4QFY20, the Navy conducted developmental/engineering flight test to examine corrective actions to a classified performance deficiency discovered during FY17 SM-6 BLK I verification of correction of deficiency tests.
- The Navy is not planning operational testing or lethality assessments for FCD mission areas. DOT&E is participating in the planning and execution of FCD developmental test events and will report, as appropriate, on these warfighting enhancements.

Assessment

- As reported in the FY18 DOT&E SM-6 BLK I FOT&E Report, the SM-6 remains effective and suitable with the exception of the classified deficiency identified in the FY13 IOT&E Report and two additional problems discovered during FY17 SM-6 BLK I testing to verify corrected deficiencies. The SM-6 BLK IA FOT&E analysis is consistent with prior reporting.
- While post-flight test data appears promising, DOT&E will assess the results of the developmental/engineering flight test to examine corrective actions to a classified performance deficiency discovered during FY17 SM-6 BLK I verification of correction of deficiency tests. This assessment will occur in FY21.

Recommendations

The Navy should:

1. Fully assess the corrective actions implemented to address the additional problems encountered during FY17 SM-6 BLK I verification of corrected deficiency tests by conducting a verification of deficiency operational flight test.
2. Plan and conduct lethality assessments for the SM-6 FCD capabilities.

Unmanned Influence Sweep System (UISS) include Unmanned Surface Vessel (USV) and Unmanned Surface Sweep System

Executive Summary

- The Unmanned Influence Sweep System (UISS) demonstrated an unmanned, semi-autonomous capability to sweep acoustically and/or magnetically actuated naval mines during November 2019 testing.
- Planned mine clearance levels were not always achieved due to inaccuracies in the planning factors established for system employment in developmental testing.
- Incomplete mission planning capabilities and data contributed to problems in effective employment of UISS for the operational assessment (OA).
- The system lacked adequate capability to inform remote operators of navigation hazards and operational minesweeping status.

System

- The UISS is an unmanned, self-propelled, semi-autonomous surface vehicle equipped with capability to sweep acoustically and/or magnetically actuated naval mines.
- The UISS is designed to be deployed, operated, and maintained from a Littoral Combat Ship, adequately equipped vessel of opportunity, or from a shore site.
- The principal UISS system components are:
  - Unmanned Surface Vehicle (USV)
  - Unmanned Surface Sweep System (US3) including a power system, magnetic field generator, an acoustic generator, and handling equipment
  - Mine Detonation Detection system
  - Command, Control, Communications, and Computers (C4) suite
  - Obstacle avoidance sensor package including a USV-mounted radar and visual surveillance system
  - For vessel of opportunity or shore-based employment, UISS is operated using a Mission Package Portable Control System

Mission

The U.S. Navy will use the UISS to provide an unmanned, organic, off-board minesweeping capability for use in littoral regions of the ocean. The UISS is the Navy's mine countermeasure asset slated to replace legacy surface ship and airborne minesweeping capabilities for mine clearance in sea lanes, straits, choke points, fleet operating areas, and amphibious objective areas.

Major Contractor

Textron Systems Corporation – Hunt Valley, Maryland

Activity

- In November 2019, the Navy's Operational Test and Evaluation Force (OPTEVFOR) conducted an OA using a DOT&E-approved test plan with fleet personnel operating the UISS from a shore site at the South Florida Ocean Measurement Facility, Florida.
- Testing deviated from the approved test plan due to high seas that limited UISS operations and compressed the limited time available for completing the OA. Operational testers completed all planned UISS missions and collected target data by reducing the operational area in order to shorten mission times.
- OPTEVFOR issued an incorrect test directive for mission planning. The UISS mission planner used this test directive to program minesweeping missions against threats with characteristics that differed from the specified threats in the approved test plan.
- The Navy used the preliminary OA results to inform the January 2020 Milestone C decision, which authorized low-rate initial production of the system.

Assessment

- The UISS demonstrated capability to sweep acoustically and/or magnetically actuated naval mines.
- The mission planning deviation from the approved test plan precluded comparison of the OA results to Navy performance requirements.
- The UISS mission planner was not adequately equipped or trained to effectively plan UISS sweep missions.
  - UISS mission planning software was not complete for the OA. The mission planner had to identify and interpret planning factors (e.g., sweep swath width and actuation probability for threat mines) from hardcopy references and manually enter them into the mission planning system to determine and program UISS sweep tracks.
  - The correct environmental data for the test area were not available in Mine Environmental Decision Aides Library (MEDAL) to support the mission planning for the OA.
  - Lacking information on the actual acoustic environment in the test area, the mission planner used incorrect planning factors for acoustic environment.
- Post-test analysis showed that planned mine clearance levels were not always achieved due to inaccuracies in the planning factors established for system employment in developmental testing.
- The UISS suffered an operational mission failure of the acoustic signal generator during the OA, but the failure was not discovered until after the OA.
- The cameras and radar installed on the USV did not provide sufficient situational awareness to ensure that a remote operator would routinely be able to detect and avoid other surface vessels and obstacles without assistance from safety boats accompanying the USV.
- The OA focused on testing the ability of UISS to sweep mines when pre-positioned at the mine danger area. Testing precluded assessment of the system's sustained area coverage rate since UISS employment for the OA was not operationally realistic. Range safety restrictions prohibited nighttime operation, and the test team had no opportunity to determine the time required to recover, quickly turn around, refuel, and re-launch the USV to continue an ongoing mission.
- The system accrued insufficient operating time during the OA to determine whether it will be able to meet the Navy reliability requirement.

Recommendations

The Navy should:

1. Complete adequate characterization of UISS sweep capabilities and update mission planning factors to improve sweep mission effectiveness.
2. Complete UISS mission planning capability and add UISS planning factors into MEDAL.
3. Install a sensing capability on the USV or the sweep system to monitor the acoustic signal generator output to increase the likelihood that the operator will recognize failures when they occur.
4. Enhance user training for planning minesweeping missions using UISS.
5. Upgrade the obstacle avoidance sensor package radar and visual surveillance systems to improve remote operator situational awareness of navigation hazards.

VH-92A Presidential Helicopter Fleet Replacement Program

Executive Summary

- The Navy is testing in accordance with the DOT&E-approved Test and Evaluation Master Plan (TEMP), dated July 24, 2005, IOT&E Test Plan, dated May 29, 2020, and Cyber Test Plan Annex, dated August 18, 2020.
- System Development Test Articles (SDTA) 1, 2, 3, and 4 are operating at Marine Helicopter Squadron HMX-1 at Marine Corps Air Facility (MCAF), Quantico, Virginia, and have flown 431.0 hours as of September 30, 2020.
- The Integrated Test Team (ITT) began testing the next version of Mission Communication System (MCS) 3.0 in January 2020. The MCS development effort has taken the deficiencies discovered in testing and made corrections.
- The Program Office realigned the start of IOT&E from June 2020 to January 2021 to provide a better progression of Marine Helicopter Squadron HMX-1 personnel training, aircraft modifications, and squadron transition from legacy aircraft to VH-92A operational missions.
- Cybersecurity test agencies were not able to send personnel to support testing in September 2020, due to travel restrictions associated with the coronavirus (COVID-19) pandemic. The cyber tests are rescheduled for March 2021.
- In August 2020, the Navy completed their consolidated report on the survivability of the VH-92A to meet the LFT&E requirements. DOT&E is currently reviewing these data as part of the final survivability assessment in support of Initial Operational Capability.

System

- The VH-92A is a dual-piloted, twin-engine helicopter based on the Sikorsky S-92. The program will maintain the Federal Aviation Administration (FAA) airworthiness certification throughout its lifecycle.
- The VH-92A aircraft will replace the current Marine Corps fleet of VH-3D and VH-60N helicopters flown by Marine Helicopter Squadron One (HMX-1) to perform the presidential airlift mission.
- The VH-92A will operate worldwide in day, night, or adverse weather conditions. The VH-92A will be air transportable to remote locations via a single Air Force C-17 cargo aircraft.

- The government-designed MCS will provide the capability to conduct simultaneous short- and long-range, secure and nonsecure, voice and data communications. The MCS will provide situational awareness by exchanging information with outside agencies, organizations, and supporting aircraft. Lockheed Martin in Owego, New York, installs the MCS hardware and baseline software and conducts systems checks as part of VH-92A production.
- Lockheed Martin will conduct final interior finishing and aircraft painting at Owego, New York, to complete the VH-92A for delivery.

Mission

- Marine Helicopter Squadron HMX-1 will use the VH-92A aircraft to provide safe and timely transport of the President of the United States and other parties as directed by the White House Military Office.
- HMX-1 will operate the VH-92A from the White House South Lawn, commercial airports, military airfields, Navy ships, and austere sites throughout the world.

Major Contractor

Sikorsky Aircraft Corporation, a Lockheed Martin Company – Stratford, Connecticut

Activity

- The Navy is testing in accordance with the DOT&E-approved IOT&E Test Plan, dated May 29, 2020, and Cyber Test Plan Annex, dated August 18, 2020.
- Engineering and Manufacturing Development (EDM)-1 and EDM-2 aircraft are at the Naval Air Station, Patuxent River, Maryland, supporting the ITT test program. As of September 30, 2020, the two EDM aircraft have accumulated 161.2 flight hours. SDTAs 1, 2, 3, and 4 are operating at Marine Helicopter Squadron HMX-1 in Quantico, Virginia, and have flown 431.0 hours.
- Naval Air Systems Command (NAVAIR) at St. Inigoes, Maryland, is continuing the development of the MCS

software. Systems integration laboratories, which replicate the MCS for development, test, and training, are operational.
- The ITT implemented manpower schedule controls to mitigate COVID-19 exposure risks. Those controls had minimal effect to program execution.
- HMX-1 personnel conducted an air transportability integrated developmental/operational test in November 2019. Helicopter Developmental Test and Evaluation Squadron HX-21, HMX-1, and PMA-274 used revised procedures and redesigned ground support equipment to disassemble, reassemble, and load VH-92A aircraft on a C-17A. The event involved HMX-1 personnel conducting a test event under the supervision of the ITT with support from an Air Force C-17A crew and equipment.
- The ITT began testing the next version of MCS 3.0 in January 2020. MCS 3.0 testing incorporated recommendations from DOT&E's VH-92A Operational Assessment OT-B1 report, dated May 28, 2019, including the use of MCS test scripts that aided in the discovery of deficiencies during the assessment. The Program Office has been addressing MCS deficiencies, discovered in testing. The ITT has tested five iterative releases of MCS 3.1 software. The NAVAIR design team continues to make improvements. The ITT will begin testing on MCS 3.2 in January 2021.
- The Program Office obtained assistance from Johns Hopkins University Applied Physics Laboratory to analyze the causes and potential mitigations for landing zone damage. The damage was found to be primarily due to engine exhaust, auxiliary power unit exhaust, and discharge of aircraft fluids onto the grass.
- The Program Office realigned the start of IOT&E from June 2020 to January 2021. The realignment provided the program and HMX-1 a better progression of HMX-1 personnel training, aircraft modifications, and transition of squadron operations to permit VH-92A to perform Presidential Lift missions within the National Capital Region in July 2021.
- HMX-1 has conducted several Integrated Test (IT) events to collect data for inclusion in the IOT&E analysis and test report. HMX-1 deployed to Peterson AFB, Colorado, to simulate a long-distance mission to support the President. HMX-1 conducted a transportability load in Quantico, Virginia, on August 18, 2020, unloaded in Colorado, conducted mission events in Colorado on August 19, 2020, and returned to Quantico, Virginia, on August 21, 2020. Preliminary data analysis indicated HMX-1 met all mission requirements with the VH-92A.
- HMX-1 conducted multiple practice contingency operations at MCAF Quantico,Virginia, on September 9, 2020. The events simulated contingency operations that the current In-Service aircraft perform. Data from the event are being analyzed and will be included in the IOT&E test report.
- Commander, Operational Test and Evaluation Force (COTF) was scheduled to conduct a cybersecurity cooperative vulnerability and penetration assessment (CVPA) and an adversarial assessment (AA) in September 2020. The testing required assistance from cyber testing experts from multiple agencies. Those agencies were not able to send personnel to support testing in September 2020 due to travel restrictions associated with COVID-19. The cyber tests are rescheduled for March 2021.
- Sikorsky maintenance personnel discovered the presence of material blisters inside both fuel cells in all six delivered VH-92A. The blisters were first discovered on EDM 2 during a regularly scheduled 24-month inspection. The program initiated an inspection for the other five VH-92As once the blisters were discovered. After analysis by Sikorsky and the fuel cell vendor, the Program Office reported that all aircraft would return to service with an additional one-time visual check before first refueling, followed by an every-50-hour fuel filter check during continued operations. NAVAIR Safety has dispositioned the issue as "No Residual Risk" upon completion of repairs. Repair planning and scheduling is ongoing, as is further analysis for causal factors and corrections.
- The Navy completed their consolidated report on the survivability of the VH-92A in August 2020. DOT&E is currently reviewing these data as part of the final survivability assessment in support of Initial Operational Capability.

Assessment
- The transportability events conducted in November 2019 and August 2020 demonstrated how HMX-1 will execute long-range missions in the real world. The revised procedures and redesigned equipment allowed HMX-1 to perform the events within program timeline requirements, and were the result of data and lessons learned during the previous air transportability demonstration HMX-1 conducted in January 2019.
- Airframe software changes have improved the aircraft availability. Aircraft publications need additional guidance to the aircrew for aircraft malfunctions and their effect on mission availability. The Program Office will deliver updated publications prior to IOT&E in January 2021.
- MCS 3.0 hardware and software show performance improvement over the MCS 2.1.3 that was tested during the FY19 Operational Assessment. MCS reliability needs additional improvements to meet the demands for operational employment. Design changes in hardware are needed, particularly intercommunication system cords, to improve the usability of communications equipment at different passenger seats in the aircraft.
- The Program Office has made procedural changes to minimize the effects of engine and Auxiliary Power Unit (APU) exhaust on Landing Zone (LZ) grass. Design changes to the airframe will prevent aircraft fluids from exiting the aircraft, and redirect APU and engine exhaust away from the LZ. The ITT has collected data on the effectiveness of these procedural and airframe changes.
- Emerging cyber threats and adversaries will require COTF to perform cyber testing that it does not have the appropriate resources to conduct. COTF should expand its cyber testing capabilities for system vulnerabilities that real-world adversaries will seek to exploit.

- Realigning the start of IOT&E provides several benefits:
  1. The program has additional time to correct emerging deficiencies in both the airframe and the MCS. HMX-1 will participate in IT of the next MCS software drop, MCS 3.2, from November – December 2020. All aircraft will be retrofit with MCS 3.2 in the December 2020 timeframe.
  2. It permits the completion of additional aircraft modifications prior to IOT&E and transition to operational assignments.
  3. It permits a more realistic timeframe to conduct adequate aircrew and maintainer training to support both IOT&E and the transition to operational assignments.
  4. It allows HMX-1 to execute IOT&E without the competing priorities of the 2020 Presidential Campaign.

Recommendations

The Navy should:

1. Ensure the cyber test teams receive resources required to conduct an adequate CVPA and AA.
2. Continue to refine aircraft publications to provide aircrew go/no-go criteria for aircraft malfunctions.
3. Ensure adequate resources to support integrated testing for future corrections of deficiencies and capability upgrades.

Air Force Programs

Air Force Programs

AC-130J Ghostrider

Executive Summary

- Preliminary DOT&E analysis of test data indicates that the AC-130J Ghostrider Block 30 upgrade provides both gun weapon systems the capability to support precision strike missions in a GPS-degraded environment.
- The U.S. Special Operations Command (USSOCOM) Airborne High Energy Laser (AHEL) system on the AC-130J is progressing towards flight demonstration in late FY22.

System

- The AC-130J is a medium-sized, multi-engine tactical aircraft with a variety of sensors and weapons for air-to-ground attack to replace the AC-130U/W aircraft.
- Nine aircrew members operate the AC-130J: two pilots, one Combat System Officer (CSO), one weapons system operator, and five special mission aviators (one sensor operator, one load master, and three gunners).
- USSOCOM developed AC-130J through the integration of a modular Precision Strike Package (PSP) onto the baseline MC-130J aircraft. The PSP includes an open architecture to allow for follow-on development and integration of block capabilities.
- The AC-130J's survivability has been upgraded to include the Advanced Threat Warning sensors for improved infrared threat detection.
- The current Block 30 PSP includes the following components and capabilities:
  - A dual-console mission operator pallet in the cargo bay that controls all subsystems with remote displays and control panels on the flight deck
  - An integrated flight deck workstation for a CSO
  - A weapon suite consisting of an internal, pallet-mounted 30-mm side-firing chain gun and 105-mm cannon; wing-mounted munitions racks for up to eight GBU-39/B GPS-guided Small Diameter Bombs (SDB), GBU-39B/B Laser SDBs, and AGM-114 HELLFIRE missiles; and 10 launch tubes in a modified cargo door for laser-guided AGM-176 Griffin missiles and GBU-69/B Small Glide Munitions
  - Two electro-optical/infrared sensor/laser designator pods (MX-20 and MX-25) and multiple video, data, and communication links
  - Improved GPS hardening to support fire control under degraded GPS conditions
  - Dual special mission processors (SMPs) that provide enhanced flight deck situational awareness and CSO control of PSP weapon functions
  - A side-mounted heads-up display to enhance pilot situational awareness of weapon engagements
- Future upgrades will equip the aircraft with an active radio frequency countermeasures (RFCM) system, Infrared Suppression System, and Advanced Threat Warning sensors for improved survivability. USSOCOM will demonstrate a prototype high-energy laser weapon on AC-130J for possible development into a program of record.

Mission

The Joint Task Force or Combatant Commander will employ units equipped with the AC-130J to provide close air support and air interdiction using battlespace wide-area surveillance, target geolocation, and precision munition employment. Additionally, the AC-130J provides time-sensitive targeting, communications, and command and control capabilities.

Major Contractor

Lockheed Martin – Bethesda, Maryland

Activity

- The 18th Special Operations Test and Evaluation Squadron (SOTES) conducted an 11-sortie, 57-flight hour Force Development Evaluation (FDE) of the Block 30 AC-130J in two phases, in 1QFY20 and 3QFY20. Testing focused on fire control performance under GPS-degraded conditions and included live fire of both guns and simulated launch of precision-guided munitions. The FDE informed a fielding and deployment release decision for the Block 30 configuration.
- The 18th SOTES also conducted cybersecurity testing through a cooperative vulnerability and penetration assessment (CVPA) in August 2019 and an adversarial assessment (AA) in June 2020, with cyber threat operations executed by the Naval

Information Warfare Systems Command Red Team for both events.

- The 18th SOTES conducted the FDE in accordance with a DOT&E-approved test plan. DOT&E reviewed and provided comments to the 18th SOTES on both cybersecurity test plans, but did not formally approve them, due to late submittal of the CVPA test plan and the coronavirus (COVID-19) pandemic effects on the AA test plan.
- COVID-19 restrictions caused an approximately 2-month delay in developmental flight test activity.
- USSOCOM awarded a new contract to Sierra Nevada Corporation in June 2020 to integrate a Northrop Grumman RFCM suite on the AC-130J in FY21. This replaces a previous RFCM contract with BAE that USSOCOM suspended in FY19.
- USSOCOM began critical design review of the AHEL system in August 2020, which is scheduled for flight demonstration on AC-130J in late FY22.

Assessment

- The Air Force has addressed four of the recommendations from the classified IOT&E report, including the most important for mission effectiveness. The Block 30 FDE demonstrated that two of the previous recommendations, specific to improving communications and datalink equipment configuration procedures, have not yet been successfully addressed.
- DOT&E analysis of Block 30 FDE data is ongoing; DOT&E will publish an operational assessment of Block 30 AC-130J in FY21. Preliminary analysis indicates:
  - Both gun weapon systems demonstrated the capability to support precision strike missions in a GPS-degraded environment with the Block 30 upgrade; specific weapon performance is classified.
  - Block 30 upgrade system usability, as measured by aircrew surveys on the System Usability Scale, improved over the Block 20 IOT&E, but remain in the "marginal" range of acceptability.
  - Operator survey responses indicate that both gun weapon systems and sensor systems experienced malfunctions throughout the FDE that degraded precision strike missions. However, FDE data do not support a statistically relevant evaluation of Block 30 reliability because Joint Reliability and Maintainability Evaluation Team (JRMET) meetings ceased after IOT&E.
  - Technical orders for operating and maintaining the Block 30 upgrade are incomplete, resulting in increased workload. Aircrew experienced difficulty configuring datalink and classified radio systems, in part because of incomplete technical data and training. DOT&E reported on this persistent problem in the Block 20 IOT&E report.

Recommendations

1. The AC-130J Program Office should:
   - Resume JRMET meetings in order to guide future reliability improvements.
   - Complete the publication of comprehensive technical data necessary for operation and maintenance of each fielded block configuration of the AC-130J, with particular focus on improving the instructions for communications and datalink systems.
2. The Air Force should update DOT&E on plans to address or accept risk on the remaining classified IOT&E report recommendations.

AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM)

Executive Summary
- The Advanced Medium-Range Air-to-Air Missile (AMRAAM), including Air Intercept Missile (AIM)-120D System Improvement Program (SIP)-2, continues to be operationally effective and suitable.
- The Air Force and Navy completed operational test activities for the AIM-120D SIP-2 in January 2020 and fielded SIP-2 in February 2020.
- The Air Force and Navy expect to begin operational test activities for the AIM-120D SIP-3 program in February 2021 and complete operational test in July 2021.
- The Air Force and Navy began combined missile cybersecurity testing in June 2018 and expect to complete testing in February 2021.

System
- AMRAAM is a radar-guided, air-to-air missile with capability in both the beyond-visual-range and within-visual-range arenas. A single aircraft can engage multiple targets with multiple missiles simultaneously when using AMRAAM.
- F-15C/D/E, F-16C/D, F/A-18C/D/E/F, EA-18G, F-22A, F-35A/B/C, and AV-8B aircraft are capable of employing the AMRAAM.
- The AIM-120D is the newest variant in the AMRAAM family of missiles. The AIM-120D includes both hardware and software improvements over the AIM-120C3-C7. Four planned follow-on SIPs will provide updates to the AIM-120D to enhance missile performance and resolve previous deficiencies.

Mission
- The Air Force and Navy, as well as several foreign military forces, employ various versions of the AIM-120 AMRAAM to conduct air-to-air combat missions.
- All U.S. fighter aircraft use the AMRAAM as the primary beyond-visual-range air-to-air weapon.

Major Contractor
Raytheon Missiles and Defense – Tucson, Arizona

Activity
- The Air Force and Navy conducted all testing in accordance with DOT&E-approved test plans.

AIM-120 SIP
- The Air Force and Navy completed operational testing of SIP-2 in January 2020.
- The Air Force and Navy expect to begin operational testing of SIP-3 in February 2021.

Cybersecurity
- The Air Force and Navy began combined cybersecurity testing of the AMRAAM in June 2018 and it is planned to be complete in February 2021.

Assessment
- AMRAAM continues to be operationally effective and suitable.
- AMRAAM modeling and simulation deficiencies were noted during SIP-2 analysis.

Recommendation
1. The Program Office should investigate and correct AMRAAM modeling and simulation deficiencies.

Air Operations Center – Weapon System (AOC-WS)

Executive Summary

- The Air Force's Kessel Run Experimentation Lab (KREL) is developing and deploying Air Operations Center – Weapon System (AOC-WS) Block 20 software to the field. The Air Force intends to conduct full operational testing once the aggregate Block 20 capability is sufficient to replace the currently-fielded AOC-WS 10.1.
- The Air Force's limited cybersecurity assessment of KREL demonstrated good cybersecurity processes, and identified risks to the mission. Additional cybersecurity testing is required for an adequate assessment.

System

- The AOC-WS (AN/USQ-163 Falconer) is a system of systems that incorporates numerous third-party software applications and commercial off-the-shelf products. Each third-party system integrated into the AOC-WS provides its own programmatic documentation.
- AOC-WS capabilities include Command and Control (C2) of joint theater air and missile defense; pre-planned, dynamic, and time-sensitive multi-domain target engagement operations; and intelligence, surveillance, and reconnaissance operations management.
- The Air Force Life Cycle Management Center (AFLCMC), Detachment 12, at Hanscom AFB, Massachusetts, is responsible for the development and sustainment of both AOC-WS 10.1 and Block 20.
- The AOC-WS consists of:
  - Commercial off-the-shelf software and hardware for voice, digital, and data communications infrastructure.
  - Government software applications developed specifically for the AOC-WS to enable planning, monitoring, and directing the execution of air, space, and cyber operations, to include:
    - Additional third-party systems that accept, process, correlate, and fuse C2 data from multiple sources and share them through multiple communications systems.
- When required, the AOC-WS operates on several different networks, including the SIPRNET, Joint Worldwide Intelligence Communications System, and coalition networks. The networks connect the core operating system and primary applications to joint and coalition partners.
- The AOC-WS Block 20 is a middle tier of acquisition (MTA) program intended to replace AOC-WS 10.1 with modernized, integrated, automated, and redundant capabilities to meet valid requirements defined for the previously canceled AOC-WS 10.2 program. The AOC-WS Block 20 enterprise is envisioned to consist of:
  - Operational AOCs using Block 20 infrastructure and software applications.
  - The AFLCMC, Detachment 12's organic KREL software factory developing the new applications.
  - Detachment 12's U.S. East Coast unit at Langley, AFB, Virginia, coordinating the delivery of Block 20 infrastructure and KREL-developed applications to the AOCs, providing sustainment and help desk capabilities, and enabling continuity of operations procedures.

Mission

The Commander, Air Force Forces or the Joint/Combined Forces Air Component Commander uses the AOC-WS to exercise C2 of joint (or combined) air forces, including planning, directing, and assessing air, space, and cyberspace operations; air defense; airspace control; and coordination of space and mission support not resident within theater.

Major Contractors

- AOC-WS 10.1 Production Center: Raytheon Intelligence, Information and Services – Dulles, Virginia
- AOC-WS Block 20 (Section 804): AFLCMC KREL – Boston, Massachusetts; Pivotal Software, Inc. – Washington, D.C.

Activity

- Substantial coronavirus (COVID-19) pandemic restrictions, such as limits to travel, access to facilities, and access to planning and analysis systems contributed to delays and limitations to cybersecurity testing of AOC-WS 10.1 and Block 20.

- The Air Force's KREL is developing and deploying AOC-WS Block 20 software to the field. The Air Force intends to conduct full operational testing when the aggregate Block 20 capability is sufficient to replace the currently-fielded AOC-WS 10.1.
- The AOC-WS 10.1 program used an Agile Release Event (ARE) construct to test and field capability updates. The 605th Test and Evaluation Squadron (605 TES) tested four AREs during FY20 (AREs 19-10, 20-02, 20-06, and 20-10). The 605 TES used a continuous risk assessment (CRA) process to determine the level of test for each ARE and then requested DOT&E review and concurrence.
- The Air Force has not performed operational cybersecurity testing on any of the eight AREs conducted since October 2018.
- In February 2020, and again in June 2020, DOT&E directed the program to accomplish full cybersecurity testing on AOC-WS 10.1 at an operational AOC to determine and mitigate cybersecurity risks to the system.
- DOT&E determined the ARE 20-06 upgrade required an operational utility evaluation with representative users operating the system to identify and mitigate possible deficiencies. The Air Force assessed the risk to test personnel conducting operational testing in a COVID-19 environment as unacceptable and decided to field ARE 20-06 without operational testing. The Air Force anticipates future testing at the first install site and each subsequent install to reduce associated risk.
- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted a limited cybersecurity adversarial assessment (AA) of KREL to assess mission risks and cyber defenses of the software factory and to obtain sufficient data on the factory's systems, networks, and processes to facilitate the development of a T&E strategy for the AOC-WS enterprise. AFOTEC conducted testing in August 2020, consistent with the DOT&E-approved test plan. Due to known test limitations on data collection and threat emulations, additional cooperative and adversarial events are necessary. AFOTEC's AA test and analysis were delayed and conducted in a remote environment due to COVID-19 restrictions.
- The 47th Cyberspace Test Squadron completed two cooperative vulnerability identification cybersecurity developmental tests on KREL and issued classified reports in November 2019 and June 2020. They also completed a congressionally mandated assessment of the AOC-WS enterprise in September 2020, with a classified report to follow once analysis is complete.
- AFOTEC provided DOT&E a draft Over-Arching Test Plan for AOC-WS Block 20 that proposes collecting operational data on individual applications via all means available to include remotely, via direct observation at KREL, and in concert with developmental testers. This aligns with DOT&E initiatives to use all test venues and assets to accomplish operationally relevant testing as soon as practical during system program development. However, the Air Force has not updated the 2011 Test and Evaluation Master Plan (TEMP) to reflect the new MTA processes.

Assessment

- The AFOTEC AA cybersecurity testing of the KREL identified risks to the KREL mission as well as disciplined defensive capabilities. DOT&E expects to issue a report in 2QFY21, once the analysis is complete.
- The Air Force adequately tested three AREs (19-20, 20-02, 20-06) in October 2019, February 2020, and June 2020 for operational effectiveness and suitability.
- The Air Force has not developed a plan to collect and report reliability, availability, and maintainability data.

Recommendations

The Air Force should:

1. Conduct adequate cybersecurity testing of both AOC-WS 10.1 and the AOC-WS Block 20 enterprise to assess current risks to AOC missions and support prioritization of remediation efforts.
2. Evaluate the cybersecurity posture of AOC-WS 10.1 as modified by eight successive AREs.
3. Submit a TEMP and applicable test plans for DOT&E approval that reflect the MTA rapid fielding process.
4. Implement a solution to meet the long-standing requirement to collect and report reliability, availability, and maintainability data for the AOC-WS.

B-52 Commercial Engine Replacement Program (CERP)

Executive Summary

- The Air Force is conducting a government-led engine source selection process with final engine selection planned for June 2021. Primary engine competitors include General Electric, Rolls Royce, and Pratt & Whitney. Competing contractors delivered side-by-side engine virtual Power Pod Prototype (vPPP) digital designs in November 2019. The vPPPs are being used to develop a complete aircraft digital design model, known as the Virtual System Prototype (vSP), which is expected to be complete in October 2021. The vPPP and vSP digital design models will provide detailed information to support physical modification of two B-52 prototype aircraft.
- DOT&E approved the initial B-52 Commercial Engine Replacement Program (CERP) Test and Evaluation Master Plan (TEMP) in March 2020. The Air Force approved a B-52 CERP Capabilities Development Document (CDD) in May 2020 to establish formal operational requirements. These documents fulfilled specified National Defense Authorization Act (NDAA) 2020 requirements.
- The B-52 CERP middle tier of acquisition (MTA) rapid prototyping development program is built around a five-phase integrated test strategy designed to maximize operational test data collection during the prototyping phase. It includes a limited operational demonstration using prototype aircraft followed by a comprehensive IOT&E using low-rate initial production (LRIP) aircraft prior to a Full-Rate Production (FRP) decision.

System

- The B-52H is a long-range, all-weather bomber with a crew of two pilots, two weapon system officers, and an electronic warfare officer.
- Mission systems include a GPS-aided precision navigation system, strategic radar targeting systems, electronic combat systems, and worldwide communications and data transfer systems.
- The B-52H can carry up to 80,000 pounds of precision-guided or unguided conventional and nuclear stores in an internal bomb bay and/or external wing pylons.

- The B-52H CERP replaces the legacy TF33 engines with fuel-efficient, commercial-derivative engines, increases electrical power generation capacity, and integrates digital engine controls and displays.

Mission

- Theater Commanders use units equipped with the B-52H to conduct long-range, all-weather conventional and nuclear strike operations that employ a wide range of munitions against ground and maritime targets in low-to-medium adversary threat environments.
- B-52 theater mission tasks include strategic attack, time-sensitive targeting, air interdiction, close air support, suppression/destruction of enemy air defenses, maritime mining, and nuclear deterrence. Key B-52H mission capabilities include:
  - Large and versatile internal and external weapons payload
  - All-weather targeting sensors and systems
  - Unrefueled intercontinental range extended by air refueling capability
  - Rapid nuclear alert start and launch capabilities
  - Nuclear-hardened and certified avionics and communication systems

Major Contractor

Boeing Defense, Space, and Security – St. Louis, Missouri

Activity

- The Air Force formally designated B-52 CERP as a rapid prototyping MTA program in September 2018, leading to acquisition of approximately 650 engines to modify and support the 76-aircraft B-52 fleet. The Air Force implemented a government-led engine source selection strategy coupled with a prime contractor-led integration program. Primary engine competitors include General Electric, Rolls Royce, and Pratt & Whitney with final selection planned in June 2021.
- The engine competitors delivered their vPPP digital models of the side-by-side engine configurations in November 2019. The individual engine vPPPs are being used to develop a complete aircraft digital model, known as the vSP planned for

completion in October 2021. These digital design models will provide detailed information to support physical modification of two B-52 prototype aircraft.

- The Air Force developed a traditional production and fleet modification strategy for the remaining 74 B-52 aircraft. This strategy includes production of 11 LRIP aircraft to support the final phase of system development testing and IOT&E. The remaining 63 aircraft would be modified in 6 FRP lots. The Air Force continues to evaluate options to accelerate production and fielding, including the potential use of the MTA rapid fielding pathway.
- The B-52 Program Office initiated a B-52 modernization program integration working group to review options for aligning the B-52 CERP development and modification program with other major B-52 modernization programs. The effort is intended to identify potential test resource and fleet modification program efficiencies to minimize impact on B-52 operational availability.
- DOT&E approved the initial B-52 CERP TEMP in March 2020. The B-52 CERP Integrated Test Team initiated sub-working groups to begin development of detailed test plans, requirements, resources, and data collection systems. The Air Force approved a B-52 CERP CDD in May 2020 to comply with NDAA 2020 direction to establish formal operational requirements for this program.
- The B-52 Program Office continued the development of a comprehensive, enterprise-level cybersecurity test strategy that will progressively conduct incremental cybersecurity assessments across multiple B-52 modernization programs, including B-52 CERP. This approach is intended to maximize cyber test efficiency while supporting cyber test requirements for multiple B-52 upgrade programs.

Assessment

- The B-52 CERP TEMP defines an initial integrated test strategy designed to maximize collection of operationally relevant test data during the prototyping phase and a limited operational demonstration of the two prototype aircraft. The TEMP also defines the test requirements and resources necessary to complete an adequate IOT&E using production-representative LRIP aircraft prior to an FRP/fleet modification decision. The Air Force should update the TEMP following the B-52 Program Office modernization program alignment review, if test resources, schedules, or test configurations change significantly.
- The Air Force Operational Test and Evaluation Center (AFOTEC) operational test strategy provides an adaptive framework to support progressive evaluation of system capabilities during prototype development. The AFOTEC operational test design, early data collection strategy, and cumulative reporting approach provide an adequate basis for tailored integration of operational testing with the B-52 rapid prototyping program. Prototype testing will culminate in an AFOTEC-led operational demonstration to assess residual conventional and nuclear mission capabilities. AFOTEC intends to leverage operationally representative prototype test data to support a final evaluation of production system operational effectiveness, suitability, and survivability across the full spectrum of nuclear, conventional, and training missions.

Recommendations

The Air Force should:

1. Continue to develop B-52 CERP detailed test plans to integrate developmental and operational test objectives during the rapid prototyping test phases.
2. Complete development of a comprehensive, enterprise-level B-52 cybersecurity strategy to establish a system cybersecurity baseline and progressively evaluate planned system upgrades while leveraging previous test results to reduce redundant testing. This strategy should integrate B-52 CERP and all other planned B-52 modernization programs with cybersecurity test requirements.
3. Review pending B-52 modernization program alignment study recommendations and modify B-52 CERP test strategy, schedules, and resources, if required.

B61 Mod 12 Life Extension Program Tail Kit Assembly

Executive Summary

- The B61 Mod 12 (B61-12) Life Extension Program (LEP) Tail Kit Assembly (TKA) program completed its IOT&E in November 2019. Operational flight testing consisted of seven weapons dropped from B-2A aircraft and eight weapons dropped from F-15E aircraft. The Department of Energy (DOE) also conducted an additional nine B61-12 drops, concluding in July 2020, which were used for operational testing (OT) reliability analysis.
- DOT&E published a classified IOT&E report in September 2020.
- In FY19, the DOE discovered an anomaly with the long-life reliability of the capacitors used in the bomb assembly (BA) Weapon Control Units (WCUs). After new capacitors were sourced and installed, DOT&E required comparison testing between the WCUs used in IOT&E and the final production WCUs. After extensive side-by-side testing completed in August 2020, DOT&E determined the WCUs used in IOT&E were production representative.
- The B61-12 TKA demonstrated high degrees of accuracy and reliability throughout IOT&E.

TKA - Tail Kit Assembly

System

- The Nuclear Weapons Council (NWC) directed the B61-12 LEP as part of the Nuclear Modernization effort. The B61-12 LEP extends the life of the original, free-fall, gravity bomb while adding a guidance capability.
- The B61-12 LEP consolidates four legacy B61 variants (Mods 3, 4, 7, and 10) into a single variant.
- The B61-12 All-Up-Round (AUR) is composed of an updated BA integrated with a new TKA. The DOE National Nuclear Security Administration (NNSA) supplies the BA and the U.S. Air Force supplies the TKA. The NNSA is updating the BA to address all age-related issues.
- The TKA is mechanically mated and electrically connected to the nuclear BA. The TKA and BA communicate with each other and with the aircraft to provide the AUR guide-to-target capability (System 2), while retaining the legacy ballistic flight capability (System 1).
- The TKA design does not include a GPS receiver. It receives pre-programmed target location data and updates from the aircraft prior to release.
- The Air Force is testing the TKA in accordance with DOD Instruction 5000.02 requirements. The NNSA leads B61-12 BA activities, and the BA subassembly will be tested and qualified per the NWC Phase 6.X Process. When mated, the BA and TKA constitute an AUR, which will be qualified in accordance with the B61-12 System Qualification Plan.

Mission

A unit equipped with the air-delivered B61-12 nuclear weapon plays a critical role in supporting the airborne leg of the nuclear triad for the United States and allies. The B61 thermonuclear bomb family is a key component of the current U.S. nuclear deterrence posture.

Major Contractor

Boeing Defense, Space & Security – St. Louis, Missouri

Activity

- The Air Force completed IOT&E in November 2019. Flight testing consisted of 15 total releases from B-2A and F-15E aircraft in operationally representative scenarios. During some sorties, the aircraft had access to GPS navigational information while in other sorties, the aircraft did not receive GPS signals the entire flight.
- The Air Force conducted IOT&E testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan.
- DOT&E published a classified IOT&E report in September 2020 which evaluated operational effectiveness, suitability, and survivability, including cybersecurity. During IOT&E, there were no reliability failures attributed to the TKA.
- In FY19, the NNSA identified new problems with the long-life reliability of commercial off-the-shelf capacitors used in non-nuclear components, including the WCU of

the BA. The NNSA completed lab testing in August 2020 of the final production WCUs, with the new capacitors, to compare performance with the WCUs used in testing. The first opportunity for flight testing of a final production WCU-equipped weapon will be in FY22 during the NNSA's retrofit evaluation system tests.

- The coronavirus pandemic caused minor delays to the WCU side-by-side comparison testing, but did not affect the DOT&E IOT&E report timeline.

Assessment

- IOT&E was adequate to assess the operational effectiveness, suitability, and survivability, including cybersecurity of the B61-12 TKA when employed by B-2A and F-15E aircraft. Results indicated the TKA demonstrates high reliability, availability, and accuracy.
- DOT&E determined that the WCUs used in the IOT&E are production representative for the purpose of IOT&E. Comparison testing of WCUs with replacement capacitors and WCUs used in OT indicates no difference in performance.

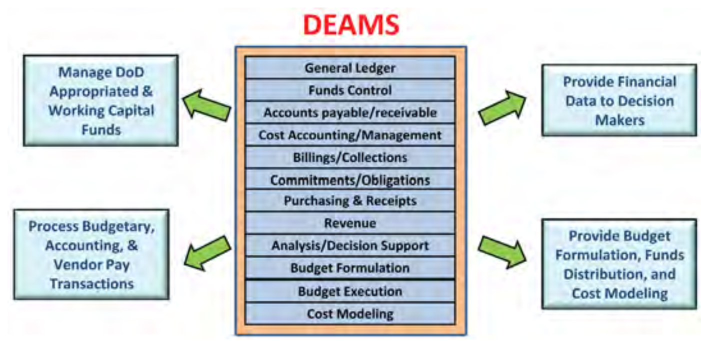
Recommendation

1. The Air Force should observe flight testing of weapons outfitted with the final production WCUs to confirm the performance is at least equivalent to that of the WCUs used during IOT&E.

Defense Enterprise Accounting and Management System (DEAMS)

Executive Summary

- In November 2019, the Program Management Office (PMO) deployed the Defense Enterprise Accounting and Management System (DEAMS) Oracle Release 12 (R12) software upgrade to thousands of Air Force users worldwide to address software obsolescence that was driving increased operational risks and maintenance costs. The FOT&E started in December 2019 and remains ongoing due to continuing problems with the system and delays related to the coronavirus (COVID-19) pandemic.
- Upon deployment of the DEAMS R12 Software Upgrade, operational users began reporting numerous major system deficiencies, greatly reducing the system's operational effectiveness and suitability. For months, the PMO's attempts to fix these deficiencies only resulted in additional deficiencies, and in July 2020, DOT&E issued an Early Fielding Report recommending the Air Force delay full deployment until all major deficiencies are addressed.
- As of September 30, 2020, the PMO has eliminated all of the critical software deficiencies.
- To prevent major fielding problems such as DEAMS experienced, DOT&E's report recommended the Air Force always fund adequate developmental and early operational testing of systems in operationally representative test environments prior to deployment to operational users.



System

- DEAMS is a Defense Business System that uses commercial off-the-shelf (COTS) enterprise resource planning software to provide accounting and management services.
- The DEAMS PMO is following an agile acquisition strategy that adds additional capabilities and users incrementally. DEAMS serves an estimated 16,600 end-users across approximately 3,900 organizations at nearly 170 locations worldwide.
- DEAMS is intended to deliver accurate, reliable, timely, and auditable financial management information through the implementation of COTS enterprise resource planning software. DEAMS performs the following core accounting functions:
  - Core Financial System Management
  - General Ledger Management
  - Funds Management
  - Payment Management
  - Receivable Management
  - Cost Management
  - Reporting
- DEAMS interfaces with approximately 40 other systems that provide travel, payroll, disbursing, transportation, logistics, acquisition, and accounting support.
- DEAMS supports financial management requirements in the Federal Financial Management Improvement Act of 1996 and the DOD Business Enterprise Architecture.

Mission

Air Force financial managers and tenant organizations use DEAMS to do the following across the Air Force, U.S. Transportation Command, and other U.S. component commands:

- Compile and share accurate, up-to-the-minute financial management data and information.
- Satisfy congressional and DOD requirements for auditing of funds, standardizing of financial ledgers, timely reporting, and reduction of costly rework.

Major Contractor

CACI – Dayton, Ohio

Activity

- In November 2019, the PMO deployed the DEAMS R12 software upgrade to thousands of users worldwide to address software obsolescence that was driving increased operational risks and maintenance costs.
- The Air Force Operational Test and Evaluation Center (AFOTEC) started the FOT&E in December 2019 with a cooperative vulnerability and penetration assessment cybersecurity test. Due to a combination of COVID-19

limitations and difficult to fix software deficiencies, FOT&E is not forecasted to complete until 2QFY21.

- Upon deployment of the DEAMS R12 Software Upgrade, operational users began reporting numerous system deficiencies. Due to COVID-19, AFOTEC adapted a hybrid test approach to include remote data collection using the Microsoft Teams application and on-site visits.
- AFOTEC observed DEAMS usage to complete Air Force accounting of End of Year financial closeout. Observations were conducted both virtually and in-person from September 24 to October 2, 2020. AFOTEC gathered data in-person at MacDill and Eglin AFBs in Florida; Microsoft Teams and other remote connectivity tools facilitated data collection with the Financial Management "War Room" at Wright-Patterson AFB, Ohio.
- DOT&E issued an Early Fielding Report in July 2020 that informed this report.

Assessment

- Since the deployment of the DEAMS R12 Software Upgrade, the discovery of software deficiencies grew at a rate that exceeded deficiency resolution and peaked with 22 severity 1 (Critical) and 105 severity 2 (Major) software deficiencies. After months of deficiency resolution efforts, which early on were creating numerous additional deficiencies, the PMO reached zero severity 1 software deficiencies on September 14, 2020. The PMO is implementing agile developmental efforts to stabilize and reduce the level of severity 2 software deficiencies. As of September 30, 2020, zero severity 1 and 82 severity 2 software deficiencies remain in the operational system. The significant number of major software deficiencies has compromised the operational effectiveness of DEAMS.
- One example of a critical problem that resulted in a major operational impact and many software deficiencies is the DEAMS interface with the Defense Travel System (DTS). The problem affected a significant number of Air Force personnel by delaying payment of travel vouchers. The DTS functionality had previously passed integrated testing, which indicates that the developmental testing was not robust enough to find this critical, high visibility problem. The PMO has since resolved the DTS-related deficiencies.
- A significant number of DEAMS cyber deficiencies remain based upon the findings from the December 2019 CVPA.
- A major reason the PMO's attempts to fix DEAMS problems generated new problems is the lack of an operationally representative test environment in which to test new DEAMS software patches. Configuration differences create uncertainty in test results, preclude effective verification of the root causes to functionality issues, and cause delays in the release of critical software fixes.
- The DEAMS agile development team continues to track and resolve the major deficiencies and needs to focus on improving user mission effectiveness and trust in the system prior to continuing deployment to the remaining 4,600 additional users.
- From the DEAMS Operational User Evaluation in February and March 2018 to the present, users have commented that training does not adequately prepare them for site-specific nuances in workflow. AFOTEC is evaluating training on the effectiveness of using site-specific workflows in the ongoing FOT&E.

Recommendations

- For DEAMS, the Air Force should:
  1. Address cybersecurity vulnerabilities that present a high risk to DEAMS missions.
  2. Continue to improve DEAMS training, with a focus on site-specific workflows.
- For all Air Force programs in agile development, to avoid fielding systems that do not support critical missions, the Air Force should resource programs adequately so that they can:
  1. Conduct robust, integrated developmental testing in an operationally representative test environment using operational users and end-to-end mission thread scenarios to reduce the risk of discovering significant software deficiencies after deployment.
  2. When functional and/or regression testing fails, correct the failures and verify the corrections with subsequent testing prior to proceeding with the release.
  3. Minimize customization of COTS software to help avoid problems during software upgrades. Keep track of any customization and ensure the upgrades are funded to account for customization. Fund adequate business process reengineering training to enable users to complete missions using the upgrade.

F-15 Eagle Passive Active Warning Survivability System (EPAWSS)

Executive Summary

- The Eagle Passive Active Warning Survivability System (EPAWSS) is performing as expected at this point in its development and test cycle. The Air Force has tested some radar warning and countermeasure functions, and identified software issues are being corrected.
- The first contractor and government developmental cybersecurity testing was completed in FY20 and no major problems were identified. Additional government cybersecurity testing is planned for FY21.
- The limited number of flight test hours accomplished during FY20 is insufficient to assess operational suitability; however, a hardware issue was identified, and the redesign is undergoing test.
- In October 2020, DOT&E provided the Air Force with a classified assessment of the available integrated test and evaluation (IT&E) results that informed the Air Force's Milestone C Decision Point 1.

System

- EPAWSS is a defensive system designed to provide F-15 aircrews with situational awareness of, and countermeasures against, radio frequency (RF) surface and airborne threats. It is designed to integrate and replace three of the F-15 legacy Tactical Electronic Warfare System (TEWS) components: the AN/ALR-56C Radar Warning Receiver, AN/ALQ-135 Internal Countermeasures Set, and AN/ALE-45 Countermeasures Dispenser Set.
- The EPAWSS radar warning function scans the RF environment and provides the aircrew with identification and location information on potential threat signals. If necessary, the system can respond with countermeasures (jamming or expendables) to defeat the threat radar or missile.
- EPAWSS was intended to replace the TEWS on the F-15C and F-15E aircraft. This year, the Air Force directed that the F-15C be excluded from the EPAWSS upgrade because the F-15C will be replaced by the new F-15EX aircraft. The EPAWSS test program is now focused on the F-15E as the lead aircraft.

Mission

- The Air Force employs the F-15E Strike Eagle as a dual-role fighter, designed to perform air-to-air and air-to-ground missions. EPAWSS provides the primary defensive suite to protect the F-15E during the conduct of both offensive and defensive missions.
- The Air Force plans to employ the F-15EX in an air-to-air role similar to the F-15C aircraft it will replace. It is planned to be an air superiority fighter, flown by active duty and Air National Guard units, and designed to perform both offensive and defensive air-to-air missions. EPAWSS will provide the defensive suite to protect the F-15EX during counter-air missions.

Major Contractor

The Boeing Company – St. Louis, Missouri

Activity

- DOT&E approved the Milestone B Test and Evaluation Master Plan (TEMP) in 1QFY18; a TEMP update is planned for 4QFY21, midway between the Milestone C program Decision Points, per agreement with DOT&E.
- The Air Force continued EPAWSS IT&E activities during FY20. Specific accomplishments included an installed system test event at Benefield Anechoic Facility (BAF), Edwards AFB, California, and three hardware-in-the-loop test events at the Multi-Spectral Test and Training Environment (MSTTE), Eglin AFB, Florida; the Integrated Demonstrations and Applications Laboratory (IDAL), Wright-Patterson AFB, Ohio; and the Advanced Threat Simulator System (ATSS), Point Mugu, California. The Air Force also accomplished flight testing on early versions of the EPAWSS software on the open-air ranges at MSTTE, and the Nevada Test and Training Range (NTTR), Nellis AFB, Nevada.

- The Air Force accomplished the following during EPAWSS IT&E:
  - Integration of the EPAWSS with an F-15E aircraft, its associated avionics, and weapons during an installed system test at the BAF in 2QFY20.
  - Evaluation of the EPAWSS radar warning function in dense RF signal environments at the IDAL in 3QFY20. An initial assessment of the countermeasures function was also completed.
  - Development of countermeasures techniques against two threats at the ATSS during 4QFY20.
  - Flight testing of the initial EPAWSS software, and the EPAWSS-related software changes to both the F-15Es Advanced Display Core Processor II (aircraft mission computer) and the AN/APG-82 radar.
  - Boeing conducted a cyber-vulnerability assessment of EPAWSS at their St. Louis, Missouri, F-15 Electronic Systems Integration Lab in July 2020, followed by the Air Force's first cooperative vulnerability identification test in August 2020.
- In October 2020, DOT&E provided the Air Force with a classified assessment of the available IT&E results that informed the Air Force's Milestone C Decision Point 1.

Assessment

- EPAWSS is performing as expected at this point in its development and test cycle.
- The Air Force has not yet completed the planned F-15 aircraft cybersecurity baseline evaluation. The results of this platform-level cybersecurity evaluation may affect the scope of the planned EPAWSS cybersecurity testing, scheduled for FY22.
- No significant cybersecurity vulnerabilities have been identified to date.

Recommendation

1. The Air Force should conduct a cybersecurity test and evaluation of the F-15 platform to properly inform the EPAWSS cybersecurity test and evaluation.

Family of Beyond Line-of-Sight Terminals (FAB-T) with Force Element Terminal (FET) and Presidential National Voice Conference (PNVC)

DOT&E submitted a Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) Early Fielding Report in 1QFY21 that is not releasable to the public. Once additional test data are collected and analyzed, DOT&E will submit a classified report.

Global Positioning System (GPS) Enterprise

Executive Summary

- The GPS Enterprise continues to experience program delays in two of its three segments (the user terminal and satellite control segments). The Military GPS User Equipment (MGUE) Increment 1 program – the user segment – will re-baseline the Air and Maritime cards to incorporate delays by the end of 2020. The control segment continues to experience delays to the Next Generation Operational Control System (OCX) due to hardware and software problems and the coronavirus (COVID-19) pandemic.
- The Space Force conducted operational testing on the current Operational Control Segment (OCS), which included Contingency Operations (COps) and M-code Early Use (MCEU). COps and MCEU were necessary software upgrades to the OCS required by the delay in the delivery of OCX. COps and MCEU performed well during operational testing.
- DOT&E has identified the following significant GPS Enterprise operational risks:
  - More work is needed to comprehensively replicate cybersecurity threats to determine their effects on the Enterprise to include mitigation efforts and a comprehensive strategy to counter those threats.
  - The MGUE Increment 1 program continues to experience delays integrating the new technology into the lead platforms and in developing final software and hardware builds by MGUE vendors.
  - Ongoing schedule slips to OCX, to include a 10-month delay for the hardware replacement effort and up to a 2-month delay for COVID-19, increases the probability of conflicts between the baseline OCX program and the OCX 3F program necessary to operate the GPS IIIF satellites.

System

- The GPS Enterprise is a satellite-based global radio navigation system of systems that provides military and civil users accurate position, velocity, and time.
- The GPS Enterprise consists of three operational segments:
  - Space Segment – The GPS spacecraft constellation consists of satellites in medium Earth orbit. The current constellation consists of 31 operational satellites comprised of Block IIR (launched from 1997-2004), Block IIR-M (2005-2009), Block IIF (2010-2016), and GPS III (first launched in 2018) satellites.
  - Control Segment – The GPS control segment consists of primary and alternate GPS master control stations, satellite ground antennas, a pre-launch satellite compatibility station, and geographically distributed monitoring/tracking stations. The GPS control segment includes:

AFSCN – Air Force Satellite Control Network
GPS IIR – Global Positioning System (GPS) Block II "Replenishment" Satellites
GPS IIR-M – GPS Block II "Replenishment – Modernized" Satellites
GPS IIF – GPS Block II "Follow-On" Satellites
GPS III – GPS Block III Satellites

    - The OCS/Architecture Evolution Plan, which the U.S. Space Force's 2nd Space Operations Squadron uses to operate the GPS satellite constellation
    - The Launch, Anomaly, and Disposal Operations (LADO), which previously launched the IIF satellites and currently supports anomaly resolution and disposal operations for the legacy Block II satellites
    - The Launch and Checkout Capability (LCC)/Launch and Checkout System (LCS), which launches and initializes GPS III satellites
    - The Selective Availability/Anti-Spoof Module (SAASM) Mission Planning System (SMPS), which provides U.S. Space Command the capability to task navigation warfare effects in support of the Combatant Commanders
  - User Segment – Various models of military GPS mission receivers are fielded on a multitude of operational systems and combat platforms.
- Modernized GPS Enterprise improvements include:
  - Space Segment – The current operational constellation includes three GPS III satellites. The GPS III Space vehicles deliver better accuracy, provide improved anti-jamming capabilities, and transmit a fourth civil signal to enable interoperability with other international global navigation satellite systems. The satellites also use a higher powered M-code signal for military use, as well as all legacy military and civil navigation signals of previous satellite blocks. The Space Force plans to acquire 10 GPS III satellites and subsequently 22 GPS III Follow-On Production (GPS IIIF) satellites. GPS IIIF will have enhancements such as regional military protection signals, support for search and rescue services, laser retro-reflector

arrays for better on-orbit position determination, and a dual band commanding capability to further command flexibility via Unified S-band.
- Control Segment – The Space Force plans to deliver OCX, which is the command and control component of the next generation GPS, in several increments, starting with Block 0 installed at the LCC/LCS in 2017. OCX will replace OCS and command all modernized and legacy satellites, and interface with updated SMPS versions. OCX Block 1 will command and control GPS Block II and III satellites. OCX Block 2 (now merged and scheduled concurrently with OCX Block 1 delivery) will provide full control of modernized civil and M-code signals and navigation warfare functions. OCX is intended to provide cybersecurity improvements over OCS. OCX Block 3F will fly the GPS IIIF spacecraft once available. Due to delays with OCX, the Space Force delivered two software upgrades to OCS: COps and MCEU. COps allows the OCS to command and control the new GPS III satellites and MCEU allows OCS to task, upload, and monitor M-code on the GPS constellation.
- User Segment – MGUE is a joint Service program developed to modernize military GPS receivers. The MGUE program is split into two increments. MGUE Increment 1 includes the GB-GRAM-Modernized form factor for the ground and low dynamic platform domains and the GRAM-Standard Electronic Module-E/Modernized (GRAM-S/M) for the maritime and aviation domains. MGUE Increment 1 performs the same core functions (signal acquisition and tracking, position, time, velocity determination, and host interfaces) as legacy GPS user equipment, but it delivers the M-code capability to the user equipment, which will improve GPS signal availability in degraded threat environments. The Air Force approved MGUE Increment 2 in November 2018 as two separate Middle Tier of Acquisition/Section 804 programs of record. Under MGUE Increment 2, the Space Force will develop (1) the Miniaturized Serial Interface form factor with a smaller Next Generation Application-Specific Integrated Circuit (ASIC) as core GPS receiver technology to support low-power applications, such as guided munitions, and address the MGUE Increment 1 ASIC obsolescence; and (2) the joint modernized handheld receiver end-item, which improves anti-jam and anti-spoof capabilities during acquisition and tracking, as well as provides longer battery life.

- Due to delays in OCX Blocks 1 and 2 delivery, the Air Force delivered and operationally accepted the COps upgrade in March 2020, as a "bridge capability"/risk mitigation effort to enable employment of GPS III satellites using legacy (pre-M-code) signals for operational constellation sustainment until OCX is delivered. Additionally, OCS MCEU will deliver operational use of core M-code, with full M-code functionality delivered in OCX Blocks 1 and 2. Space Force is expected to operationally accept MCEU in November 2020.

Mission

Combatant Commanders of U.S. and allied military forces use GPS to provide accurate position, navigation, and time information to operational users worldwide. GPS also supports a myriad of non-military users worldwide.

Major Contractors

- Space Segment
  - Block IIR/IIR-M/III/IIIF satellites: Lockheed Martin Space Systems – Denver, Colorado
  - Block IIF satellites: Boeing, Network and Space Systems – El Segundo, California
- Control Segment
  - OCS, COps, and MCEU: Lockheed Martin Space Systems Division – Denver, Colorado
  - OCX: Raytheon Technologies, Intelligence, Information, and Services – Aurora, Colorado
- User Segment (MGUE Increment 1)
  - L3Harris Technologies, Inc. – Anaheim, California
  - Raytheon Technologies, Space and Airborne Systems – El Segundo, California
  - BAE Systems – Cedar Rapids, Iowa

Activity

- All operational testing is in accordance with the GPS Enterprise Test and Evaluation Master Plan (E-TEMP) approved by DOT&E on September 13, 2018.
- Schedule slips in development of the ground and control GPS segments have caused operational testing delays from dates listed in prior DOT&E Annual Reports. Operational testing was completed in 2020 on two software upgrades to OCS: COps and MCEU. These are stop-gap capabilities due to delays in delivery of OCX. MGUE Increment 1 card delays have pushed operational testing to FY21.
  - In FY20, the Space Force conducted developmental test and evaluation (DT&E) for the space, control, and user segments. Testing included the Mission Readiness and On-Orbit Checkout Tests for GPS III satellites 02 and 03, integrated system of tests for GPS III/COps and MCEU, early OCX Block 1 testing, and MGUE Increment 1 card-level testing in the labs and also integrated into two lead platform vehicles.
  - The Program Office is revising the GPS E-TEMP to address an updated space threat test strategy, cyber testing, concurrent delivery of OCX Blocks 1 and 2, MGUE Increment 2, an upgraded Nuclear Detonation Detection System control system, GPS IIIF satellites, and OCX Block 3F.

COVID-19

- The GPS Enterprise was affected by COVID-19 during FY20, which resulted in testing delays and development schedule slips.
  - The OCX program reported a 4 to 10-week schedule slip due to constraints within work spaces and self-isolation. OCX worldwide monitoring station deployments and testing have been affected by travel restrictions imposed by other countries resulting in a 3-month delay.
  - The MGUE Increment 1 program experienced delays to DT&E activities in spring 2020 due to travel restrictions and quarantine requirements. Temporary closures of the labs and personnel constraints have contributed to schedules slips of ongoing card-level testing and development and delivery.

Control Segment

- The U.S. Space Force Star Delta Provisional Detachment 4 currently plans to conduct OT&E of OCX in FY23 during the GPS Enterprise Multi-Service OT&E (MOT&E) that will include OCX and GPS III satellites. Operational testing will be conducted to support OCX Operational Acceptance following transition of constellation control from OCS to OCX, followed by full M-code MOT&E to include M-code user segment systems. The MOT&E will inform both the Positioning, Navigation, and Timing Initial Operating Capability (IOC) as well as the Constellation Management IOC.
- Detachment 4 completed operational testing of COps in February 2020, concurrent with GPS III SV01 operational testing. The Space Force operationally accepted COps in March 2020.
- MCEU operational testing began in August 2020 and completed in October 2020. MCEU testing was conducted to verify the OCS could task, upload, and monitor M-code within the GPS constellation. Control Segment testing will include the six worldwide distributed GPS M-code capable monitoring stations. MCEU results were not completed at the time of the annual report.

Space Segment

- The Air Force, and subsequently the Space Force, successfully launched the first 3 of 10 GPS III satellites into orbit in 2018, 2019, and 2020, respectively. The satellites have undergone successful checkout and have now operationally joined the GPS constellation.
- In 2018, the Air Force contracted Lockheed Martin to build 22 GPS IIIF satellites. The first GPS IIIF satellite will be available for launch no later than 2028, but current estimates forecast 2026.

User Segment

- In 2018, the Air Force Service Acquisition Executive approved the MGUE Increment 2 acquisition strategy. This approval resulted in the release of a draft Request for Proposal announcement for the MGUE Increment 2 receiver card in 2019 and expected contract award in FY21.
- The Program Office completed system-level developmental testing with MGUE Increment 1 cards integrated into the two ground lead platforms.
- MGUE OT&E will be followed by the two-phase GPS Enterprise MOT&E in FY23, with the second phase incorporating user equipment, using both lead and non-lead platforms.

Assessment

- The Space Force has improved the GPS Enterprise planning by addressing schedule and performance risks; however, articulation of program risks with OSD stakeholders continues to be incomplete, increasing the probability of unmitigated risks causing further program delays.
- The Lead Developmental Test Organization is effectively managing the breadth of developmental testing activities, emerging test requirements, and significant changes to test plans; however, due to the Space and Missile Systems Center reorganization, the staff has taken on more responsibilities and activities leading to delays in planned revisions to the E-TEMP.

Control Segment

- OCX had delays in Product Test completion and increased discrepancy reports within Segment Integration, along with delays in contractor equipment deliveries have driven increasingly tight and compressed developmental testing schedules.
- Operational Acceptance expected by the Space Force occurred in November 2020.

Space Segment

- GPS space vehicles lack requirements to address cybersecurity survivability threats; however, that does not preclude the need for operational testing against the full characterization of adversary threats against the system.
- The Program Office continues to develop a space threat plan to address adversary threats against the system as directed in DOT&E's "Guidance on Threat Representation in Operational Testing and Evaluation of Space Systems" memorandum, dated September 24, 2019.
- The Air Force made the GPS IIIF Milestone C decision in July 2020 based on completion of Critical Design Review, prior to development or testing of any GPS IIIF satellites. The first launch is expected in 2026 due to the high level of commonality of GPS III and GPS IIIF satellites. Acquiring sufficient test articles is imperative to test the satellites prior to launch.
- With the advice and assistance of DOT&E, Detachment 4 conducted cybersecurity testing on the GPS III satellite simulator in October 2020.

User Segment

- The MGUE Increment 1 program continues to face challenges meeting the aviation and maritime technical requirements.

- Ongoing delays of final software and hardware builds by MGUE Increment 1 vendors continue to cause delays to MGUE Increment 1 lead platform test schedules, which increases the risk for platforms seeking to implement MGUE before lead platform testing is complete. Due to imminent closure of the production line, final purchases of MGUE Increment 1 ASIC technologies from the trusted foundry production lines have been completed, prior to full completion of testing to verify the ASIC's operational performance.

Recommendations

The Space Force should:

1. Continue to plan to conduct operational testing of the GPS Enterprise against current and emerging space threats to assess the ability of the system and its operators to support DOD missions in a contested space environment.
2. Improve the process to inform users of GPS across the DOD of GPS Enterprise test results and schedule delays, to enable users to plan for integration of new GPS capabilities.
3. Conduct regular Enterprise-wide testing events to gauge GPS ability to support the warfighter using the new M-code capabilities. This will provide insight into the status of each segment relative to the others and the M-code capabilities the overall system will provide to the warfighter.
4. Provide the expected availability of the M-code capabilities to the warfighter, including the availability of MGUE cards for operational use.
5. Conduct a threat specific test or MOT&E-like event involving a no-notice transfer to the Alternate Master Control Station to verify system survivability.
6. Include cyber survivability requirements into all future acquisition programs to ensure systems can address and respond to adversarial threats.

Ground Based Strategic Deterrent (GBSD)

Executive Summary

- The Ground Based Strategic Deterrent (GBSD) program entered the Engineering and Manufacturing Development (EMD) phase after the Milestone Decision Authority signed the Milestone B (MS B) Acquisition Decision Memorandum on September 4, 2020.
- The DOT&E-approved GBSD Test and Evaluation Master Plan (TEMP) describes an adequate and integrated T&E strategy that relies heavily on the use of modeling and simulation.
- The GBSD Program Manager, with guidance and support from DOT&E, completed the first phase of a cybersecurity risk assessment of the Digital Engineering System (DES), which is a cloud-based development and testing environment.

System

- GBSD is a recapitalization for the Minuteman III Intercontinental Ballistic Missile (ICBM) weapon system.
- The GBSD program comprises two major segments: the Aerospace Vehicle Equipment (AVE) segment and the Command and Launch (C&L) segment. Both segments include all associated trainers, test support equipment, transport equipment, maintenance support equipment, and depot support equipment used to operate and maintain GBSD.
- The AVE segment is an integrated missile stack, which includes the following major sub-components: Booster stages and interstages, Post-boost Vehicle, Missile Guidance Set, Reentry System, and Reentry Vehicle.
- The C&L segment encompasses all launch command and control equipment including the Secondary Launch Platform, Launch Center equipment, Launch Facility equipment, and Integrated Command Center equipment. The C&L segment includes all communications and facility infrastructure.

Mission

- The U.S. Strategic Command will use the GBSD to execute operational plans as directed by the President of the United States.
- GBSD is an ICBM nuclear warhead delivery system that provides safe, secure, responsive, global capability both to deter potential adversaries and to assure allies, and if necessary, decisively defeat adversary targets and retaliatory capabilities.

Major Contractors

- Northrop Grumman – Roy, Utah
- Northrop Grumman Space Systems – Chandler, Arizona
- Bechtel – Reston, Virginia
- Textron – Wilmington, Massachusetts

Activity

- The Milestone Decision Authority signed the MS B Acquisition Decision Memorandum on September 4, 2020, and the Air Force awarded the EMD contract on September 8, 2020.
- The Program Office built the DES, which is both a development environment and a T&E venue built on a cloud-based infrastructure provided by the DOD Chief Information Officer for Special Access Programs (DOD SAP CIO). The Program Office intends to use the DES as a data repository as well as the means to facilitate data sharing among the geographically separated government and contractor teams.
- The GBSD Program Office coordinated with DOT&E and DOD SAP CIO to conduct a cybersecurity risk assessment of the GBSD DES. The DES cybersecurity testing is a three-phased test and part of the planned continuous cybersecurity testing of both the development environment and the weapon system. The cybersecurity risk assessment will help the program manager decide when the DES can safely store and distribute sensitive data.
- DOT&E approved the GBSD MS B TEMP to include the LFT&E Strategy in August 2020. The GBSD TEMP describes an integrated T&E strategy. The flight test design carefully integrates developmental and operational testing goals; hence, each flight test should provide useful data for evaluation. The LFT&E Strategy describes the evaluation framework needed to assess the survivability of AVE and C&L segments

with all appropriate support equipment, and the lethality of the weapon system.
- The integrated test strategy relies heavily on the DES and the modeling and simulation tools. The work on verification, validation, and accreditation of those tools began during the Technical Maturity and Risk Reduction phase, prior to MS B.
- The Program Office will coordinate an update to the TEMP based on the additional program and technical information from the EMD Baseline Review with the prime contractor.
- The Program Office and the Air Force Test and Evaluation Center (AFOTEC) created a Combined Test Force (CTF) to design and execute integrated testing. The CTF integrates developmental and operational testing but preserves AFOTEC's independence.

Assessment
- The first phase of the DES cybersecurity risk assessment found no significant vulnerabilities.
- The GBSD Program Office's implemented innovative approaches should help reduce cybersecurity and schedule risks. These approaches include:
  - Building a cybersecurity defense team as a part of the GBSD Mission Defense Team as a part of an exemplary strategy to defend the system from cybersecurity adversaries.
  - System Theoretic Process Analysis for Security, which links vulnerabilities to operational impact. This process is integral to the GBSD cybersecurity plans, and provides a rigorous analytical basis for test design and analysis.
  - Implementing Model Based System Engineering, and creating a lab environment that integrates the requirement management system, architectural products, and component designs. The integrated system-engineering environment will be a valuable testing asset once AFOTEC accredits it for operational test data collection.
- DOT&E, USD(R&E), and the GBSD Program Office are developing test methodology for nuclear hardening and survivability test tools and methods. The updated TEMP will include this approach.

Recommendations

None.

HH-60W Jolly Green II

Executive Summary

- The HH-60W Program Office projects developmental test will complete by 2QFY21.
- The operationally representative versions of some key capabilities, such as hover symbology in degraded visual environments and survivability equipment threat definition files, will not be available until after the start of IOT&E.

System

- The HH-60W Jolly Green II is a new-build, dual-piloted, twin-engine rotary-wing aircraft, based on the Army UH-60M, to replace the Air Force HH-60G. The HH-60W will fly a combat radius of at least 195 nautical miles without aerial refueling and conduct an out-of-ground effect hover at its mid-mission gross weight.
- The HH-60W includes survivability enhancements intended to be equivalent to, or better than, the current HH-60G aircraft:
  - Cockpit and cabin armor, self-sealing fuel cells that do not suffer catastrophic damage from high-explosive incendiary rounds, and crew and passenger crashworthy seating
  - Two external mount gun systems with forward and side-firing crew-served weapons including the GAU-2B, GAU-18, and GAU-21
  - Aircraft survivability equipment including the AN/AAR-57(V)3 common missile warning system, the AN/ALE-47 countermeasures dispenser set, the AN/AVR-2B(V)1 laser detecting system, and the AN/APR-52(V)1 radar warning receiver (RWR)
  - An upturned exhaust system to reduce its infrared signature.

Mission

- Commanders will employ units equipped with the HH-60W to:
  - Recover isolated personnel from hostile or denied territory, day or night, in adverse weather, and in a variety of threat environments from terrorist to chemical, biological, radiological, and nuclear (CBRN).
  - Conduct humanitarian missions, civil search and rescue, disaster relief, medical evacuation, and non-combatant evacuation operations.

Major Contractor

Sikorsky Aircraft Corporation – Stratford, Connecticut

Activity

- In 1QFY20, Sikorsky delivered the sixth and seventh aircraft to support government developmental test.
- The HH-60W program expects to complete developmental testing in December 2020, a roughly 3-month delay. Avionics software regression testing contributed to the delay.
- The coronavirus (COVID-19) pandemic caused marginal delays in flight testing and travel to ranges, but the test team continued operations in alternating shifts at Duke Field, Florida.
- The Air Force conducted on-aircraft testing of the RWR in the Joint Preflight Integration of Munitions and Electronic Systems anechoic chamber from November 2019 to January 2020, and open-air range testing February to March 2020. Additional RWR testing is scheduled in 1QFY21 at the end of developmental testing.
- In March 2020, the Air Force conducted extreme weather testing on an aircraft in the McKinley Climate Lab at Eglin AFB, Florida, including rain, heat, and arctic conditions.
- The Air Force conducted electromagnetic environment testing at Naval Air Station Patuxent River, Maryland, from March to April 2020.
- The Air Force Operational Test and Evaluation Center (AFOTEC) issued a periodic report in May 2020, focusing on the RWR system.
- The Air Force conducted a fourth cybersecurity cooperative vulnerability identification in October 2019 and two phases of adversarial cybersecurity developmental testing in July and September 2020.
- In August 2020, the Air Force completed the live fire testing of the cockpit and cabin armor to support the evaluations

of survivability and force protection against operationally representative kinetic threats.
- In May 2020, the Air Force completed the live fire testing of the aerial refueling system and self-sealing fuel hoses in a flight-representative configuration.
- The Air Force continued planned analytical efforts to evaluate aircraft system-level vulnerability and force protection against kinetic energy weapons, directed energy weapons, electromagnetic, and CBRN threats.

Assessment
- AFOTEC identified poor hover symbology in degraded visual environments as a risk to IOT&E.
- Developmental tests of the external gun system identified deficiencies that increase workload and risk to crew members in some reloading scenarios, and gun mount binding problems that could limit weapon effectiveness and safety.
- On-aircraft chamber and open-air range testing of the RWR demonstrated progress toward mission capability, but some deficiencies remain. The RWR threat definition files are still developmental and not tailored to anticipated operational threats, resulting in excessive spurious detections. The HH-60W program does not have a plan to develop updated threat definition files in time to support the IOT&E. Additionally, the display of threat information (including infrared, laser, and small arms threats as well as RWR data) overlayed on the primary flight display for excessively long periods, obscuring navigation information.
- The Air Force acquired the necessary data to evaluate the aircraft survivability and force protection against operationally realistic kinetic energy threats.
- The armor did not demonstrate equivalent multi-hit performance to the currently fielded HH-60G armor; the effect on overall system survivability and force protection is pending. Self-sealing fuel hoses of the aerial refueling system demonstrated limited vulnerability to dry bay fire.

Recommendations

The HH-60W program should:
1. Update threat definition files and software to provide operationally representative RWR capability and hover symbology prior to the IOT&E.
2. Continue to support cybersecurity testing by providing test teams with access to all components, software, and support equipment.

KC-46A Pegasus

Executive Summary

- As of October 2020, the Air Force had accepted 38 of the expected 179 KC-46A aircraft.
- In support of the IOT&E, the program certified 9 of the 17 different receiver aircraft types for KC-46A aerial refueling and completed the required flight testing to support the certification of six additional receivers. B-2A testing is ongoing and A-10 testing has been deferred.
- The A-10 is anticipated to be certified for aerial refueling operations once the KC-46A stiff aerial refueling boom deficiency is resolved. The design resolution and implementation is anticipated to be complete in FY23.
- The program completed developmental testing of the wing aerial refueling pods (WARP), supporting the certification requirements that are expected to be finalized in mid-FY21.
- As of October 2020, the Air Force Operational Test and Evaluation Center (AFOTEC) had completed approximately 63 percent of all planned test points.
- In February 2020, AFOTEC conducted simulated aeromedical evacuation missions, which were followed by real aeromedical evacuation missions with live patients to Pacific and Atlantic bases outside the continental United States.
- In January 2020, AFOTEC resumed cargo missions following Boeing's correction of cargo pallet locks inadvertently unlocking during flight. Revamped cargo floor loading calculations, allowing efficient cargo pallet loading, have significantly improved cargo operations. However, forward barrier net limitations on cargo placement continue to hinder cargo operations.
- In coordination with the Defense Threat Reduction Agency and DOT&E, the Air Force developed a plan to test KC-46A against operationally realistic electromagnetic effects. Continuous wave testing was completed in November 2020 with electromagnetic pulse testing planned for May 2021.
- In May 2020, DOT&E decided not to issue an IOT&E report in support of a Full-Rate Production decision because the redesigned Remote Visual System (RVS) testing has not been completed. The redesigned RVS testing is anticipated to occur in FY23.

System

- The KC-46A air refueling (AR) aircraft is the first increment of 179 replacement tankers for the Air Force fleet of more than 400 KC-135 and KC-10 tankers.
- The KC-46A design uses a modified Boeing 767-200ER commercial airframe with numerous military and technological upgrades, such as the fly-by-wire refueling boom, the remote air refueling operator's station, 787 cockpit displays, additional fuel tanks in the body, and a range of survivability enhancement features:
    - Susceptibility is reduced with an Aircraft Survivability Equipment suite consisting of Large Aircraft Infrared Countermeasures (LAIRCM), a modified version of the ALR-69A Radar Warning Receiver (RWR), and a Tactical Situational Awareness System (TSAS).
    - Vulnerability is reduced by adding a fuel tank inerting system and integral armor to provide some protection to the crew and critical systems.
- The KC-46A will provide both a boom and probe-drogue refueling capabilities, and is also equipped with an AR receptacle so that it can receive fuel from other tankers, including legacy aircraft.
- The KC-46A is designed to have significant palletized cargo and aeromedical capacities; chemical, biological, radiological, and nuclear survivability; and the ability to host communications gateway payloads.

Mission

Commanders will use units equipped with the KC-46A to perform AR in support of six primary missions: nuclear operations support, global strike support, air bridge support, aircraft deployment support, theater support, and special operations support. Commanders will use units equipped with the KC-46A to also accomplish the following secondary missions: airlift, aeromedical evacuation, emergency AR, air sampling, and support of combat search and rescue.

Major Contractor

The Boeing Company, Commercial Aircraft in conjunction with Defense, Space & Security – Seattle, Washington

Activity

- As of October 2020, the Air Force accepted 38 of 179 KC-46A aircraft at the following four air bases: McConnell AFB, Kansas; Altus AFB, Oklahoma; Pease AFB, New Hampshire; and Seymour Johnson AFB, North Carolina.
- In support of the IOT&E, the program completed aerial refueling certification of 9 of the 17 planned aircraft types to receive fuel from KC-46A (B-52, C-17A, C-130, F-15, F-16, F/A-18C/D, F/A-18E/F, KC-46A, F-35A). Flight testing to support certification of six additional receiver aircraft (B-1B, C-5M, CV/MV-22, E-3G, F-22A, P-8) is complete while B-2A testing is ongoing. The A-10 testing has been deferred and is awaiting the stiff boom redesign, which will not be completed until FY23.
- The Program Office completed developmental testing of the WARPs and expects to certify it in mid-FY21.
- AFOTEC continued execution of the IOT&E, which began in May 2019, in accordance with the DOT&E-approved test plan. As of October 2020, AFOTEC completed approximately 63 percent of all planned test points. AFOTEC cannot complete the remaining test points until the Air Force corrects deficiencies on the KC-46A.
- In November 2019, Boeing delivered a materiel correction for the deficiency where cargo pallet latches became inadvertently unlocked during flight. In December 2019, AFOTEC tested the new locking system, determined the problem had been resolved, and resumed cargo mission testing in January 2020.
- The Air Force conducted a flight test demonstration in June 2020 of the initial increment of a Boeing-proposed update to correct the major deficiency in the RVS of poor visual acuity. Boeing is working on an interim upgrade to the existing RVS system, Enhanced RVS, as well as a long-term redesign, designated as RVS 2.0. The KC-46A program currently projects flight testing RVS 2.0 in FY23.
- The Air Force conducted aeromedical evacuation missions with live patients to Pacific and Atlantic bases outside the United States in September and October 2020.
- The Air Force completed analyses to assess the KC-46A's inherent nuclear hardness to blast, radiation, flash, thermal, and electromagnetic pulse effects and to assess base safe escape in the event of a nuclear attack.
- The Air Force has coordinated with the Defense Threat Reduction Agency and DOT&E to develop a plan to test KC-46A against operationally realistic electromagnetic effects. Continuous wave testing was completed in November 2020 with electromagnetic pulse testing planned for May 2021.
- AFOTEC completed the Cyber Vulnerability Penetration Assessment in October 2020 and conducted the cyber Adversarial Assessment in December 2020.
- Coronavirus (COVID-19) pandemic travel and operation restrictions suspended IOT&E flight test activity for approximately 90 days but, due to cascading effects on mission scheduling, the total delay in test point completion and cybersecurity test events is currently 4 months.

Assessment

- Operational test data collection and analysis are ongoing, so there is no overall assessment at this time.
- Revamped cargo floor loading calculations, allowing efficient cargo pallet loading, have significantly improved cargo operations. However, forward barrier net limitations on cargo placement continue to hinder cargo operations.
- Because the Air Force will not conduct operational testing of a fully mission-capable RVS until FY23, DOT&E does not consider the current aircraft configuration to be completely production representative. Therefore, in May 2020, DOT&E informed the Assistant Secretary of the Air Force for Acquisition that DOT&E will not issue an IOT&E report in support of a Full-Rate Production decision until testing of the redesigned RVS is complete.
- Other long-term deferred test points include:
  - TSAS testing, pending RWR deficiency corrections anticipated in FY21
  - WARP operational testing pending completion of the developmental test report in mid-FY21
  - Boom refueling of light aircraft, such as the A-10, pending high boom stiffness corrections anticipated in mid-FY23

Recommendation

1. The Air Force should continue to test and certify receiver aircraft to refuel from the KC-46A to support IOT&E receiver refueling evaluations.

MH-139A Grey Wolf

Executive Summary
- The MH-139A Grey Wolf acquisition strategy relies on expanding existing civil flight certifications to obtain the military flight release required for government developmental test.
- Delays in the civil certification process have propagated to the remainder of the test program and may limit the information required to support the Milestone C decision.
- For most expected engagement conditions, the cockpit and cabin armor solution did not provide the required protection against the specification small arms threat.

System
- The MH-139A Grey Wolf is a dual-piloted, twin-engine helicopter that will replace the legacy UH-1N helicopter.
- Boeing is developing the MH-139A as a commercial derivative aircraft by integrating military communication, navigation, transponder, and survivability enhancement features to the baseline Leonardo AW139, including:
  - Cockpit and cabin armor
  - Self-sealing crashworthy fuel cells
  - AN/AAR-47 missile warning system and AN/ALE-47 countermeasures dispenser set
  - Two externally mounted M240 crew-served weapons
- The MH-139A is designed to accomplish 3 hours of unrefueled flight or a 225 nautical mile range, and a cruise speed of 135 knots.
- The MH-139A is intended to carry nine combat equipped troops and security response equipment.

Mission
- Air Force Global Strike Command will use the MH-139A to support the nuclear security missions by providing emergency security response and convoy escort at Minot AFB, North Dakota; Malmstrom AFB, Montana; and Francis E. Warren AFB, Wyoming.
- Air Force District Washington will use MH-139A to provide contingency response, continuity of operations, and airlift for senior government officials in the National Capital Region.
- In addition, MH-139A-equipped units will conduct secondary missions for multiple commands:
  - Pacific Air Forces will provide operations support for key personnel based at Yokota Air Base, Japan.
  - Air Force Materiel Command will provide test range support to Eglin AFB, Florida, and developmental test aircraft from Duke and Hurlburt Fields, Florida.
  - Air Education and Training Command will provide formal flight training at Maxwell AFB, Alabama, and medical evacuation and support operations to the Air Force Survival School at Fairchild AFB, Washington.
- All commands will perform search and rescue via the National Search and Rescue Plan and Defense Support to Civil Authorities.

Major Contractor
The Boeing Company, Defense, Space, and Security – Ridley Park, Pennsylvania

Activity
- The MH-139A acquisition strategy relies on conducting the initial phases of flight test with the aircraft owned and operated by Boeing under a Civil Aircraft Operations (CAO) certification. Boeing will use the test events flown under the CAO to obtain a series of supplemental type certification (STC) approvals from the Federal Aviation Administration.
- The STC process has slipped over a year from the original plan of October 2019. Contractor flight testing to support STC approvals is ongoing at Duke Field, Florida, and contractor facilities in Philadelphia, Pennsylvania. The STCs required to support a military flight release (MFR) and government developmental testing are now estimated for FY21.

- The coronavirus (COVID-19) pandemic affected test operations by inhibiting travel of Air Force and contractor flight crew and support personnel. COVID-19 also contributed to delays in logistics support from Leonardo in Italy, but the program's overall critical path was not significantly affected by COVID-19 restrictions.
- In an attempt to recover from the STC delays, the program is revising its test strategy to rely more heavily on government-observed, contractor-performed flight test. Dedicated government developmental flight testing will be curtailed and refocused on remaining air vehicle specification verification in direct support of the MFR, and on some additional military utility evaluation events.
- The 47th Cyberspace Test Squadron conducted two cooperative vulnerability identification events in April and May 2020 on a partially modified AW-139 that was not production representative. The third cybersecurity test event on a production-representative MH-139A has been delayed.
- The Air Force Operational Test and Evaluation Center (AFOTEC) published a series of periodic reports based on their observations and participation in the test program.
- In July 2020, following completion of contractor qualification testing of the cabin and cockpit armor solution, the Air Force 704th Test Group completed the first phase of live fire evaluation of the MH-139A armor against expected small arms threats in accordance with the DOT&E-approved test plans.
- The Air Force is currently developing test plans to evaluate the damage effects of expected small arms threats against the main gearbox, main rotor blade, and the tail rotor blade.
- The Air Force is developing plans to perform electromagnetic pulse hardness testing in late FY21.

Assessment

- The revised test strategy increases risk to the program. The current STC schedule delays the MFR causing a subsequent delay to the majority of government weapons, defensive systems, and envelope expansion flight test events. This delay will limit the test data available to inform the scheduled Milestone C decision.
- Use of civil certifications instead of government developmental testing may not adequately inform some areas of military utility. For example:
  - Aircraft performance and handling qualities at high altitude, hot temperatures, and heavy weight for airworthiness and certification may not accurately represent the capability of the aircraft to conduct military flight profiles at these demanding conditions.
  - Contractor testing of emergency crew egress from the MH-139A-configured cabin may not reveal obstacles encountered by a fully equipped security force in the operational environment.
- Reliance on contractor data during developmental testing risks increasing the scope of the IOT&E unless conducted during military utility events.
- AFOTEC periodic reports highlighted several areas of risk in the system design:
  - Expansion of the flight performance envelope is likely to stress engine components and increase maintenance requirements.
  - The MH-139A cabin configuration is different than the legacy UH-1N and the layout presents challenges to the employment of a security force.
  - The commercial landing gear design may not support tactical landings on unprepared surfaces in austere locations.
  - The commercial aircraft's flight manual includes restrictions on takeoffs in crosswinds or near obstacles that hinder military operations.
- Contractor testing of the gun mount has revealed multiple design deficiencies that must be corrected to ensure safe operation of the gun weapon system.
- For most expected engagement conditions, the cabin and cockpit armor did not provide the required protection against the specification threat. The armor also did not provide adequate protection against another, operationally representative small arms threat at all relevant ranges.
- The Air Force has a requirement for the MH-139A to include infrared signature suppression that is currently not part of the aircraft design.

Recommendation

1. The MH-139A program should develop an updated event-driven schedule that supports adequate test and evaluation program in time to inform acquisition and operational decisions.

Small Diameter Bomb (SDB) II

Executive Summary

- The Air Force completed Multi-Service Operational Test and Evaluation (MOT&E) Phase I flight testing and LFT&E of the Small Diameter Bomb (SDB) II on the F-15E Strike Eagle in December 2019, releasing a total of 59 weapons.
- MOT&E Phase I flight test missions built upon the capabilities demonstrated in Government Confidence Testing (GCT). This included demonstrating the ability to successfully engage a target with multiple weapons on a single pass, operate in a GPS-jamming environment, perform a commanded abort, employ an exclusion zone, and override the exclusion zone to engage a target.
- DOT&E published a classified MOT&E Phase I early fielding report in July 2020.
- The Air Combat Command authorized fielding of the SDB II on the F-15E on September 23, 2020.
- The Navy initiated a quick reaction assessment (QRA) in FY20 to enable fielding on the F/A-18E/F by January 2021 within a limited employment envelope.
- Further operational test (OT) on the F/A-18 E/F is scheduled to continue in FY21. MOT&E Phase II activities on F-35B and C are scheduled to begin in FY21 and continue into FY24. The program will accomplish a Full-Rate Production (FRP) decision upon completion of F-35 B/C testing.
- The Air Force continues to advocate for initiatives to streamline the cryptographic information delivery, loading, and verification process. The current process complicates the ability to employ the SDB II in normal attack (NA) mode at standoff range.
- Lethality analysis indicates the weapon performs as expected against target surrogates for legacy main battle tank, infantry fighting vehicle, anti-aircraft gun, surface-to-air missile target-erector-launcher, rocket launcher, and small patrol boat.

System

- The SDB II is a 250-pound, air-launched, precision-glide weapon that uses deployable wings to achieve standoff range.
- The Air Force directed the design of the SDB II to achieve the capabilities deferred from SDB I. Capability improvements include a weapon datalink and multi-mode seeker.
- The weapon datalink allows post-launch tracking and control of the weapon, which provides standoff employment capability against mobile targets.

- In addition to a GPS and an Inertial Navigation System, to achieve precise guidance accuracy in adverse weather, the SDB II employs the millimeter-wave radar component of the multi-mode seeker.
- The NA mode is used primarily to strike mobile targets in adverse weather. The Laser Illuminator Attack (LIA) mode is used to guide the weapon to a laser spot generated by the launching aircraft or a third party source. The Coordinate Attack (CA) mode is used primarily to strike stationary targets and can be used in adverse weather.
- The SDB II incorporates a multi-function warhead (blast, fragmentation, and shaped-charge jet) designed to defeat armored and non armored targets. The weapon can be set to initiate on impact, at a preset height above the intended target, or in a delayed mode.
- An SDB II-equipped unit or Joint Terminal Attack Controller (JTAC) will engage targets in dynamic situations and use a weapon datalink network to provide in-flight target updates, in-flight retargeting, weapon in-flight tracking, and if required, weapon abort.

Mission

Combatant Commanders will use units equipped with the SDB II to attack stationary and moving ground and littoral targets in adverse weather conditions at standoff ranges.

Major Contractor

Raytheon Missiles and Defense – Tucson, Arizona

Activity

- The Air Force completed MOT&E Phase I operational test flights using the F-15E in May 2019. In total, the F-15E released 59 weapons, encompassing 43 NA, 8 CA, and 8 LIA missions. The program flew the test plan-required 56 releases plus 2 additional releases due to hardware failures and 1 additional release due to previously failed maritime target mission.
- With the exception of cybersecurity testing, the Air Force conducted MOT&E Phase I testing in accordance with the

DOT&E-approved Milestone C Test and Evaluation Master Plan (TEMP) and test plans. DOT&E published a classified MOT&E Phase I F-15E early fielding report in July 2020.
- The Air Force submitted a waiver package in October 2020 to the National Security Agency (NSA) which requests relief from some of the cryptographic key handling requirements for SDB II employment from the F-15E.
- The Air Force has reached a price agreement for the Low-Rate Initial Production lot 6 contract for 1,208 weapons (747 Air Force, 461 Navy) and plans to award the contract in October 2020.
- The Navy initiated a QRA in late FY20 to enable fielding on the F/A-18E/F in early 2021 within a limited employment envelope. The coronavirus (COVID-19) pandemic caused moderate delays to the F/A-18E/F QRA, which may delay initial operating capability by 3 months.
- MOT&E Phase II on the F-35B and C in FY21 and FY22 will further characterize its operational effectiveness against small patrol boats, and to evaluate carrier/shipboard operability. Phase II will also include captive flight tests to provide data for employment against additional types of maritime targets. The SDB II Program Office will accomplish an FRP decision following the completion of MOT&E Phase II.
- The Air Combat Command authorized fielding of the SDB II on the F-15E on September 23, 2020.
- The Air Force and Navy are in the process of updating the Milestone C TEMP based on the results of MOT&E Phase I. This update will drive the specifics of MOT&E Phase II.

Assessment
- MOT&E Phase I and LFT&E were adequate to evaluate SDB II effectiveness, lethality, and suitability. Cybersecurity testing of the SDB II was not adequate to holistically evaluate the weapon's survivability in a cyber-contested environment. However, the cyber assessments provided good characterization of the cyberattack surface, insight into the interfaces between the SDB II and supporting equipment, and a working knowledge of how the weapon and support equipment process messages. The classified DOT&E early fielding report contains further details.
- MOT&E Phase I flight test missions built on the capabilities demonstrated in GCT by showing the ability to successfully engage a target with multiple weapons on a single pass, operate in a GPS-jamming environment, perform a commanded abort, and both employ an exclusion zone and override the exclusion zone to engage a target.
- In the CA mode, the system performed as expected with all weapons hitting at appropriate distances from the planned coordinates provided to the weapon. In the LIA mode, all weapons hit in very close proximity to the directed laser spot.
- The weapon performs well in NA mode against moving targets if it receives valid targeting data. Two factors affected the weapon receiving valid targeting data during MOT&E Phase I: the cumbersome process for loading Link 16 datalink cryptographic information and the lack of a DOD standard JTAC ultrahigh frequency (UHF) datalink kit.
  - The process to load Link 16 datalink cryptographic keys is cumbersome due to NSA protection requirements for national security systems. These requirements mandate the keys used for F-15E SDB II mission planning be split into multiple keys to enable secure transfer to the aircraft and weapon. Splitting the keys complicates the preflight process as cryptographic key verification on the aircraft, weapons, and mission planning systems is not possible prior to mission time. The waiver package submitted to the NSA, if approved, should eliminate many of the cyptographic key complications encountered during MOT&E Phase I.
  - During testing, JTACs used multiple different UHF datalink kits. The lack of JTAC familiarity with the different kits, particularly their ability to ensure the kit was compatibly keyed to transmit data to the weapon, resulted in incorrect targeting data being passed to the weapon.
- Mission planning is also a significant challenge, with average planning times of over 50 minutes per weapon (the threshold time is 5 minutes per weapon). Much of this is related to a time intensive, error prone cryptographic data entry process, and a poor exclusion zone creation process.
- Lethality analysis indicates the weapon performs as expected against target surrogates for legacy main battle tank, infantry fighting vehicle, anti-aircraft gun, surface-to-air missile target-erector-launcher, rocket launcher, and small patrol boat. The detailed lethality analysis appears in the classified DOT&E early fielding report.
- The Air Force did not conduct MOT&E Phase I cybersecurity on an operational SDB II test article, which limited the relevance and validity of the test data.

Recommendations
The Air Force and Navy should:
1. Develop a MOT&E Phase II cybersecurity test and evaluation strategy.
2. Continue to improve the mission planning cryptographic data entry and exclusion zone creation processes to decrease the mission planning timeline.
3. Characterize lethality against modern main battle tanks.
4. Update the Milestone C TEMP to address MOT&E Phase I cybersecurity shortfalls.
5. Ensure future SDB II cybersecurity testing includes the use of an operationally representative test article and operational users.
6. Investigate options for standardizing JTAC UHF datalink kits for use in MOT&E Phase II.

Space Fence (SF)

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted an IOT&E of Space Fence (SF) Increment 1 from August 6 through November 1, 2019. Testing was adequate to determine SF operational effectiveness, suitability, and survivability when supporting the Space Force's Space Domain Awareness (SDA) mission.
- SF is operationally effective. Its observations improved the Space Force's SDA by cataloging previously untracked space objects and significantly increasing the total number of objects maintained in the satellite catalog.
- SF is operationally suitable. It maintained sufficient operational availability to support the SDA mission. However, operator workload was high because of system latencies on the operator network, requiring the use of the maintenance network as a workaround.
- SF is not survivable against insider or nearsider limited to moderate cyber threats. Testing discovered cybersecurity problems that could deny or degrade SF operations.

System

- SF is a space surveillance S-Band radar system integrated into the Space Surveillance Network (SSN). SF detects, tracks, identifies, and characterizes man-made Earth-orbiting objects in space.
- SF's primary capability is un-cued detection and tracking of objects (satellites, space debris, etc.) in low Earth orbit (LEO), with additional capability to detect and track objects in medium Earth orbit (MEO) and geostationary equatorial orbit (GEO).
- SF deployed Increment 1, which consists of a radar site at Kwajalein Atoll and an Operations Center co-located with the Reagan Test Site Operations Center in Huntsville, Alabama. Increment 2, a second radar site in Australia, is currently unfunded.

Mission

The 18th Space Control Squadron located at the Combined Space Operation Center uses SF to maintain a constant surveillance of man-made objects in space to support the SDA mission. SF provides high fidelity, un-cued, and cued radar observations from LEO, MEO, and GEO to the SSN. SF data supports the 18th Space Control Squadron satellite catalog maintenance and processing of space events (e.g., satellite maneuvers and breakup events).

Major Contractors

- Lockheed Martin Rotary and Mission Systems – Moorestown, New Jersey
- General Dynamics Mission Systems – Plano, Texas

Activity

- The Air Force conducted developmental test and evaluation (DT&E) from April to August 2019, in preparation for operational testing.
- AFOTEC conducted cybersecurity testing from January 28 to February 8, 2019; August 19 – 28, 2019; and September 9 – 19, 2019, to determine the cyber survivability of the system.
- AFOTEC and the Joint Navigational Warfare Center conducted GPS-resilience testing of the system in August 2019.
- AFOTEC conducted an IOT&E in accordance with the DOT&E-approved test plan from August 6 to November 1, 2019, with one exception: testing the radar in Flexible Coverage Mode was not completed in its entirety as planned.
- During DT&E and IOT&E, the Joint Interoperability Test Command (JITC) conducted an evaluation of the SF Net-Ready Key Performance Parameters.
- DOT&E also used data from the Air Force-conducted operational trial period in November through March 2020 to support the IOT&E report.
- The Space Force declared both initial operational capability and operational acceptance of SF on March 27, 2020.
- DOT&E published an SF IOT&E report in June 2020.

Assessment

- Testing was adequate to determine SF operational effectiveness, suitability, and survivability; however, competing test priorities limited the DOT&E assessment of the radar in Flexible Coverage Mode for space debris characterization.
- SF is operationally effective. SF improved the Space Force's SDA mission by increasing the frequency of tracking cataloged objects and by cataloging previously untracked space objects, significantly increasing the total number of objects maintained in the satellite catalog.
- Though the evaluation of SF in Flexible Coverage Mode was limited, the radar demonstrated the capability to track objects roughly the size of a cherry in LEO. With only one sensor site, SF does not have the power to continuously detect, track, and maintain awareness of all of these small objects.
- SF testing revealed two effectiveness concerns:
  - The system's parameters for operator-directed detection and tracking were not optimized for small, cube-shaped satellites, which are proliferating widely.
  - Switching between the primary and backup frequency and timing sources affects metric accuracy (some accuracies increase, while others decrease), but does not prevent SF from meeting accuracy requirements.
- SF is operationally suitable. It maintained sufficient operational availability to support the SDA mission. While SF was available to support mission needs, testing revealed three noteworthy suitability concerns:
  - Operators, system administrators, and system maintainers received insufficient training from Lockheed Martin to configure the system prior to testing.
  - High network latency caused status differences between operations and maintenance consoles, increasing operator workload.
  - System software instabilities caused the mean time between critical failures (MTBCF) to be two orders of magnitude worse than required, despite repeated attempts to resolve the concerns with software patches during IOT&E.
- SF operators are able to input taskings into the SF system. However, the system did not initially consistently plan, schedule, or conduct tasks correctly, leading to an increase in operator workload to monitor automatic taskings and missed observations. Software patches installed prior to regression testing largely addressed this problem, making the tasking process more streamlined for the user.
- Available system and user documentation lacked final corrections, processes, and procedures prior to operational testing. Incomplete documentation resulted in operators being unable to complete some tasks in a timely manner without subject matter expert involvement.
- SF is not survivable against insider or nearsider limited to moderate cyber threats. Testing discovered cybersecurity problems that could deny or degrade SF operations. Although some scenario-driven data collection was conducted, it did include an assessment of the local defenders' reactions to cyber threats. DOT&E will publish the cybersecurity findings, along with other threat-based testing results, in the classified annex of the SF IOT&E report.

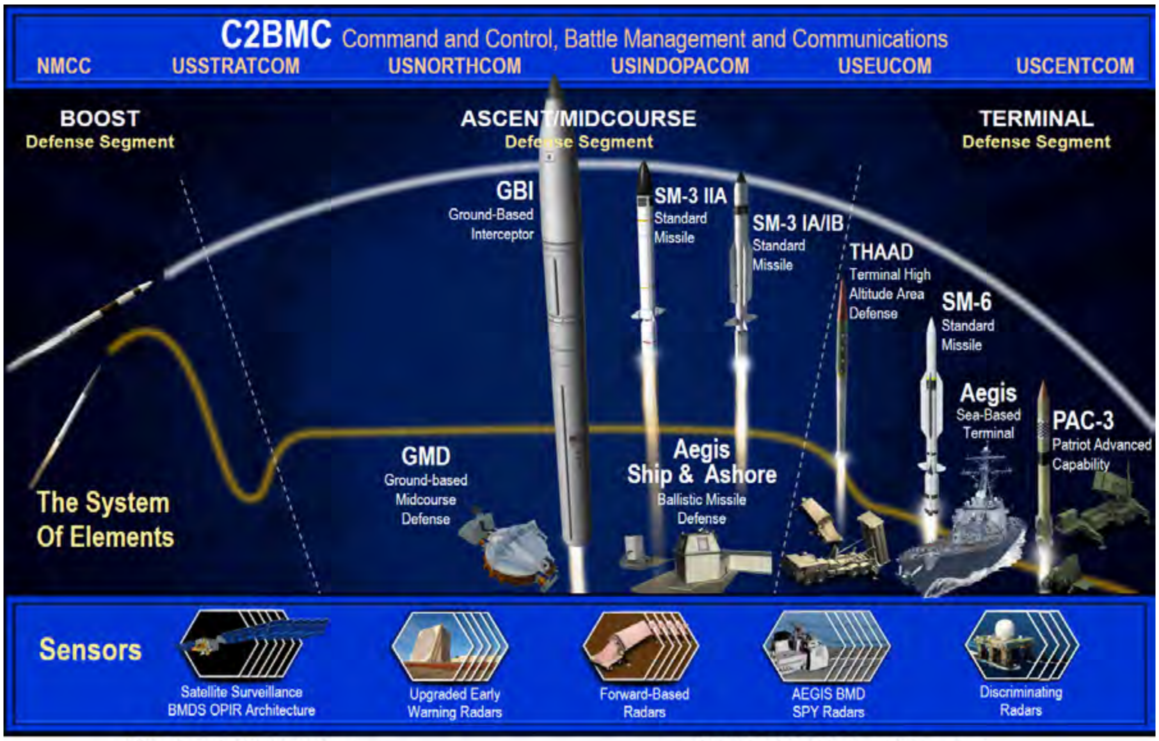
Recommendations

1. The Space Force should modify operator-directed tracking to account for larger-than anticipated changes in radar cross section for cubic satellites, and retest the probability-of-detection requirement.
2. The SF Program Office should address the following:
   - Mitigate metric accuracy discrepancies between primary and backup frequency and timing sources, and retest to ensure that they produce commensurate results.
   - Characterize the Flexible Coverage Mode for its utility in supporting debris surveys.
   - Develop robust SF training programs for new operators, system administrators, and system maintainers.
   - Reduce the high network latency that caused differences between operations and maintenance consoles.
   - Continue to perform root-cause analyses of software failures, and implement system patches and fixes as necessary.
   - Mitigate all cybersecurity exposures and vulnerabilities identified during operational cyber testing before follow-on testing.
3. The Space Force should coordinate with AFOTEC and the SF Program Office to plan and conduct a follow-on cybersecurity adversarial assessment that focuses on the responses of the system defenders to adversarial activity and the verification of fixes to previously open cyber findings.

Ballistic Missile Defense Systems

Ballistic Missile Defense Systems

Ballistic Missile Defense System (BMDS)



BMD - Ballistic Missile Defense
BMDS - Ballistic Missile Defense System
NMCC - National Military Comand Center
OPIR - Overhead Persistent Infrared

USCENTCOM - U.S. Central Command
USEUCOM - U.S. European Command
USINDOPACOM - U.S. Indo-Pacific Command
USNORTHCOM - U.S. Northern Command
USSTRATCOM - U.S. Strategic Command

Executive Summary

- The Ground-based Midcourse Defense (GMD) weapon system has demonstrated capability to defend the U.S. Homeland from a small number of intermediate-range ballistic missile (IRBM) or intercontinental ballistic missile (ICBM) threats (greater than 3,000 km range) with simple countermeasures when the Homeland Defense Ballistic Missile Defense System (BMDS) employs its full architecture of sensors/command and control.
- The Regional/Theater BMDS has demonstrated capability to defend the U.S. Indo-Pacific Command (USINDOPACOM), U.S. European Command (USEUCOM), and U.S. Central Command (USCENTCOM) areas of responsibility from small numbers of medium-range ballistic missile or IRBM threats (1,000 to 4,000 km range) and short-range ballistic missile threats (less than 1,000 km range).
- The Missile Defense Agency (MDA) continued to mature BMDS operational effectiveness in FY20 during 16 test events, 3 live fire investigations, 7 wargames, and 15 exercises across 5 Combatant Commands. The MDA did not conduct full system-level Homeland Defense flight testing, Regional/Theater Defense flight testing, or operational cybersecurity testing in FY20.
- The MDA strengthened the linkage between test schedules and acquisition decisions, such as Operational Capability Baseline decisions, technical capability declarations, or materiel production decisions. While a productive start, the MDA needs to increase emphasis on completing all testing ahead of these programmatic acquisition decisions.
- Quantitative evaluation of BMDS operational effectiveness is dependent on modeling and simulation (M&S), and M&S activities are expanding rapidly. The MDA should emphasize completing both developmental and operational M&S accreditation in support of its programmatic acquisition decisions.

System

The BMDS is a geographically distributed system of systems that relies on element interoperability and warfighter integration for operational capability and efficient use of guided missile/interceptor inventory. The BMDS consists of a sensor/command and control architecture and four weapon systems.

- Sensors – COBRA DANE radar; Upgraded Early Warning Radars (UEWRs); Sea-Based X-band (SBX) radar; Aegis AN/SPY-1 radar aboard Aegis Ballistic Missile Defense (BMD)

ships; AN/TPY-2 (Forward-Based Mode (FBM) and Terminal High-Altitude Area Defense (THAAD) Mode) radars; Space-Based Infrared System (SBIRS); BMDS Overhead Persistent Infrared Architecture (BOA); a network of space sensors known as Space-based Kill Assessment (SKA); and the Long Range Discrimination Radar (LRDR), currently under construction.
- Command and Control – Command and Control, Battle Management, and Communications (C2BMC).
- Weapon Systems – GMD, Aegis BMD/Aegis Ashore Missile Defense System (AAMDS), THAAD, and Patriot Advanced Capability-3 (PAC-3).

Mission

The Commanders of U.S. Northern Command, USINDOPACOM, USEUCOM, and USCENTCOM employ the assets of the BMDS to defend the United States, deployed forces, and allies against ballistic missile threats of all ranges.

Major Contractors

- The Boeing Company
  - GMD Integration: Huntsville, Alabama
- Lockheed Martin Corporation
  - Aegis BMD, AAMDS, AN/SPY-1 radar, and LRDR: Moorestown, New Jersey
  - C2BMC: Huntsville, Alabama, and Colorado Springs, Colorado
  - SBIRS: Sunnyvale, California
  - THAAD Weapon System, PAC-3 Command and Launch System, and PAC-3 interceptor variants: Dallas, Texas
  - THAAD Interceptors: Troy, Alabama
- Northrop Grumman Corporation
  - GMD Booster Vehicles: Chandler, Arizona
  - GMD Communications Network (GCN), Launch Management System (LMS), and Ground Fire Control (GFC): Huntsville, Alabama
  - BOA: Boulder, Colorado; Colorado Springs, Colorado; and Azusa, California
- Raytheon Technologies Corporation
  - GMD Exo-atmospheric Kill Vehicle and Standard Missile (SM)-2/3/6 Interceptors: Tucson, Arizona
  - PAC-3 Ground System and PAC-2 interceptor variants, AN/SPY-6 radar, AN/TPY-2 radar, SBX radar, and UEWRs: Tewksbury, Massachusetts
  - COBRA DANE Radar: Dulles, Virginia
- L3 Harris Technologies
  - GMD In Flight Interceptor Communication System Data Terminals (IDT): Melbourne, Florida
- Johns Hopkins University, Applied Physics Laboratory
  - SKA: Laurel, Maryland

Activity

- The MDA conducted testing in accordance with the DOT&E-approved Integrated Master Test Plan (IMTP) as affected by the coronavirus (COVID-19) pandemic. Correspondingly, the MDA delayed and modified flight, ground, and cybersecurity test events across the BMDS; as of fall 2020:
  - One-third of the FY20 and the first half of FY21 flight tests have been delayed 2-4 quarters. The second half of the FY21 flight tests have slipped 1-2 quarters. All of the FY20-21 MDA tracking exercises of advanced targets have been delayed 2-4 quarters.
  - One FY20 ground test slipped 1 quarter; the other three tests were executed as scheduled. The initial FY21 ground tests have slipped 1-2 quarters.
  - There were no operational cybersecurity tests planned for FY20; the FY21 tests are maintaining schedule.
- During FY20, the MDA conducted three BMDS-level ground tests, seven element-level flight tests, and one element-level ground test. The MDA also conducted one tracking exercise of an advanced target, one international test, and participated in three Air Force ICBM reliability and sustainment flight tests. The MDA accomplished three GMD subscale light-gas-gun live fire tests against an ICBM target. The MDA did not conduct full system-level Homeland Defense flight tests, Regional/Theater Defense flight tests, or operational cybersecurity testing.
  - In November to December 2019, the MDA conducted a ground test of legacy Homeland Defense exo-atmospheric kill vehicle upgrades and of Capability Increment 5C functionality for USINDOPACOM Regional/Theater Defense.
  - In February 2020, the MDA conducted a ground test evaluating European Phased Adaptive Approach Phase 3 capabilities.
  - In June 2020, the MDA assessed the Patriot Missile Segment Enhancement interceptor launch-on-THAAD capability in USINDOPACOM scenarios.
  - The MDA assessed BMDS elements in 13 other test events. See the individual BMDS element articles (pages 211-222) for reporting on these tests.
- The MDA conducted 7 wargames and 15 exercises across 5 Combatant Commands in FY20 enhancing Combatant Command BMD readiness and increasing Service operator confidence in the deployed elements of the BMDS.
- The MDA revised the IMTP to incorporate BMDS element maturation, program modifications, and fiscal constraints. The most significant new addition to the IMTP this year was the inclusion of a detailed test schedule for cybersecurity tests.
- The MDA updated its rules of engagement for Persistent Cybersecurity Operations (PCO) assessments and participated in test planning for one Combatant Command PCO evaluation.

- The MDA and BMDS Operational Test Agency continued to resolve limitations that have previously prohibited independent M&S accreditation while simultaneously developing M&S capabilities in new areas of assessment and emerging threats.

Assessment

- Previous BMDS-level assessments for Homeland and Regional/Theater Defense remain unchanged:
  - The GMD weapon system has demonstrated capability to defend the U.S. Homeland from a small number of IRBM or ICBM threats (greater than 3,000 km range) with simple countermeasures when the Homeland Defense BMDS employs its full architecture of sensors/command and control.
  - The Regional/Theater BMDS demonstrated capability to defend the USINDOPACOM, USEUCOM, and USCENTCOM areas of responsibility from small numbers of medium-range ballistic missile or IRBM threats (1,000 to 4,000 km range) and short-range ballistic missile threats (less than 1,000 km range range).
- During FY20 testing, the MDA collected ground test data supporting development and fielding of new capabilities and architectures associated with BMDS Capability Increments 5B, 5C, and 6B and an urgent materiel release. Test data and resulting assessments are classified; see the DOT&E "FY20 Assessment of the BMDS," to be published in February 2021.
- The MDA has initiated a process that evaluates individual missile threats based on key features that characterize the total allocated threat space allowing assessment of emerging threats more efficiently and rapidly. Using phenomenology-based threat modeling has allowed the Sea-Based Weapon System Program Office to address the Aegis Weapon System's allocated threats while significantly reducing the number of individual target missile solutions required, thus increasing the efficacy of flight testing.
- Given the ever-changing and dynamic nature of the IMTP baseline, ensuring tests are scheduled to support their acquisition program decisions is a continual challenge for the MDA. The MDA often makes acquisition decisions based on ground test data, accepting the risk of not having data available from flight tests or operational cybersecurity assessments. The majority of ground test data come from Ground Test Integrated (GTI) tests, which the MDA conducts in a high-fidelity laboratory-based venue with emulated communications networks. Data from Ground Test Distributed (GTD) tests are generated in an operational test venue using operational communication networks, but are typically only a small subset of GTI test cases. In FY20, the MDA drafted updates to its corporate capability fielding policy and its IMTP-generation instruction to strengthen the linkage between test schedules and acquisition decisions.
- The MDA's M&S activities are expanding rapidly. The BMDS threat set, sensing environments, and communication pathways necessary in the M&S venues are growing and the framework and models are undergoing significant modifications. Flight and ground test schedules must maintain a strong linkage to enable timely M&S accreditation based on flight test data. Independent M&S accreditation ensures that the pedigree of any data generated by M&S are sufficient for programmatic acquisition decisions, and that data limitations and resulting risks are well understood by the decision-maker.

Recommendations

The MDA should:

1. Continue maturing and expanding the use of phenomenology-based threat modeling, as demonstrated by the Sea-Based Weapon System Program Office, across the agency.
2. Increase emphasis on completing all testing 6 months ahead of programmatic acquisition decisions. As enumerated in the draft update to the MDA fielding policy, 6 months are required for sufficient data analysis; M&S verification, validation, and accreditation; and MDA Corporate Board processing and coordination.
3. Begin execution of PCO on BMDS assets deployed to Combatant Commands.
4. Increase emphasis on completing both developmental and operational M&S accreditation in support of programmatic acquisition decisions.

Sensors / Command and Control Architecture

LRDR – Long Range Discrimination Radar; SBX – Sea-Based X-band; UEWR – Upgraded Early Warning Radar

Executive Summary

- The Missile Defense Agency (MDA) continued to mature the Ballistic Missile Defense System (BMDS) sensors/command and control architecture in FY20 during seven test events.
- The lack of AN/TPY-2 Forward-Based Mode (FBM) radar test assets hinders efficient test planning and scheduling. The Army typically makes one radar available for testing. This significantly limits the amount of flight testing that can be accomplished in a year.
- Modeling and simulation (M&S) of BMDS sensors continues to be a challenge. The MDA should address BMDS sensor M&S deficiencies to enable credible assessments against operationally relevant threats.
- Electronic attack and threat countermeasure testing for BMDS sensors are needed; developing an accredited M&S capability in these areas should be a high priority.

System

- An extensive set of sensors provides real-time ballistic missile threat detection, tracking, and classification/discrimination to the BMDS:
  - The COBRA DANE radar is a fixed site, L-band phased array radar.
  - Five Upgraded Early Warning Radars (UEWRs) are fixed site, ultrahigh frequency radars.
  - The Sea-Based X-band (SBX) radar is a mobile, X-band phased array radar located aboard a self-propelled, ocean-going platform.
  - The Aegis Ballistic Missile Defense weapon system includes the Aegis AN/SPY-1 radar, which can also be used as a forward-based sensor. See page 217 for reporting on the AN/SPY-1 radar.
  - The AN/TPY-2 (FBM) radar is a transportable, single-face, X-band phased array radar.
  - The Space-Based Infrared System (SBIRS) is a satellite constellation of infrared sensors.
  - The BMDS Overhead Persistent Infrared Architecture (BOA) processes infrared sensor data to provide track information on missile events.
  - The Space-based Kill Assessment (SKA) system is a network of space sensors.
  - The Long Range Discrimination Radar (LRDR) is a fixed site, two-face, S-band phased array radar; it is under construction.
- The Command and Control, Battle Management, and Communications (C2BMC) element is the integrating element within the BMDS. It provides deliberate and dynamic planning, situational awareness, sensor track management, engagement support and monitoring, data exchange between BMDS elements, and network management. It also directs sensor tasking for the AN/TPY-2 (FBM) radar, LRDR, BOA, and SKA systems.

FY20 BALLISTIC MISSILE DEFENSE SYSTEMS

Mission

Combatant Commands employ BMDS sensors to detect, track, and classify/discriminate ballistic missile threats and operate the C2BMC for deliberate and dynamic planning, situational awareness, sensor track management, engagement support and monitoring, data exchange between BMDS elements, and network management.

Major Contractors

- COBRA DANE Radar
  - Raytheon Technologies Corporation – Dulles, Virginia
- UEWRs, SBX, and AN/TPY-2 (FBM) Radars
  - Raytheon Technologies Corporation – Tewksbury, Massachusetts
- SBIRS
  - Lockheed Martin Corporation – Sunnyvale, California
- BOA
  - Northrop Grumman Corporation – Boulder, Colorado; Colorado Springs, Colorado; and Azusa, California
- SKA
  - Johns Hopkins University, Applied Physics Laboratory – Laurel, Maryland
- LRDR
  - Lockheed Martin Corporation – Moorestown, New Jersey
- C2BMC
  - Lockheed Martin Corporation – Huntsville, Alabama, and Colorado Springs, Colorado

---

Activity

- The MDA conducted testing in accordance with the DOT&E-approved Integrated Master Test Plan as affected by the coronavirus (COVID-19) pandemic. As a result, the MDA delayed several test events involving the sensors/command and control architecture; for example:
  - Two of the FY20 ground tests were executed prior to the pandemic, one was delayed 1 quarter, and one maintained schedule. Two of the three FY20 Air Force intercontinental ballistic missile (ICBM) reliability and sustainment flight tests, which the MDA participated in, were delayed until the end of this fiscal year.
  - To date, the first half of FY21 flight tests have been delayed 2-4 quarters and the second half of the FY21 flight tests have slipped 1-2 quarters. The initial FY21 ground tests have slipped 1-2 quarters.
- During FY20, the MDA assessed the sensors/command and control architecture in four ground tests and participated in three Air Force ICBM reliability and sustainment flight tests:
  - In November to December 2019, the MDA conducted a ground test of legacy Homeland Defense exo-atmospheric kill vehicle upgrades and of Capability Increment 5C functionality for U.S. Indo-Pacific Command Regional/Theater Defense.
  - In February 2020, the MDA conducted a ground test evaluating European Phased Adaptive Approach Phase 3 capabilities.
  - In June 2020, the MDA assessed the Patriot Missile Segment Enhancement interceptor launch-on-Terminal High-Altitude Area Defense capability in U.S. Indo-Pacific Command scenarios.
  - In July 2020, the MDA conducted an AN/TPY-2 (FBM) radar System Integration and Checkout ground test for future Site 4c deployment.
  - The Air Force conducted three ICBM flight tests in FY20 that included MDA sensors/command and control architecture assets. The SBX radar, SKA network of space sensors, and the C2BMC command and control element participated in all three events.
- The MDA oversaw LRDR requirements verification testing using a subscale array at the contractor's test facilities. The operational LRDR arrays have been installed and are undergoing initial checkout.
- The MDA fielded two SBX radar software upgrades.
- The MDA incorporated operational use of the Cape Cod UEWR and SBIRS version 19-1 into the fielded BMDS.
- The Air Force fielded UEWR software upgrades at two locations.

Assessment

- The MDA continued to mature the BMDS sensors/command and control architecture in FY20.
- During FY20 testing, the MDA collected sensor/command and control data supporting development and fielding of new capabilities and architectures associated with BMDS Capability Increments 5B, 5C, and 6B and an urgent materiel release. Test data and resulting assessments are classified; see the DOT&E "FY20 Assessment of the BMDS," to be published in February 2021.
- The lack of AN/TPY-2 (FBM) radar test assets hinders efficient test planning and scheduling. The Army typically makes one radar available for testing. This significantly limits the amount of flight testing that can be accomplished in a year. The MDA is exploring radar emulation for the AN/TPY-2 (FBM) radar, but use of radar emulation reduces operational realism in testing and limits the use of these data for M&S accreditation.
- Immature M&S of BMDS sensors continues to be a challenge that prevents adequate assessments of BMDS performance. For example, the COBRA DANE radar model cannot accept a dynamic input, such as interceptor debris and the UEWR models have never been accredited. The MDA plans to make a fielding decision for the LRDR based on M&S results, but

prior to data being available to accredit the M&S, which adds risk to the decision. Ground and flight test threat M&S for BMDS sensors cannot adequately represent current threat missiles, electronic attack, countermeasures, debris, or raid sizes.

Recommendations

The MDA should:

1. Pursue acquisition of an additional AN/TPY-2 (FBM) radar to facilitate more efficient BMDS testing.
2. Continue to mature the AN/TPY-2 (FBM) radar emulation concept.
3. Address BMDS sensor M&S deficiencies to enable credible assessment against operationally relevant threats.
4. Include electronic attack and threat countermeasure testing for BMDS sensors and develop an M&S capability in these areas.

Ground-Based Midcourse Defense (GMD)

Executive Summary

- The Ground-based Midcourse Defense (GMD) weapon system has demonstrated capability to defend the U.S. Homeland from a small number of intermediate-range ballistic missile (IRBM) or intercontinental ballistic missile (ICBM) threats (greater than 3,000 km range) with simple countermeasures when the Homeland Defense Ballistic Missile Defense System (BMDS) employs its full architecture of sensors/command and control.
- GMD participated in one ground test, one developmental cybersecurity test, and three live fire tests.
- The Missile Defense Agency (MDA) fielded improved capability for both the Capability Enhancement-I (CE-I) and CE-II Exo-atmospheric Kill Vehicles (EKVs), and an upgrade to the GMD Launch Management System (LMS).
- The MDA released a Request for Proposal for the Next Generation Interceptor (NGI) and is currently assessing proposals received from multiple bidders.
- Ground-Based Interceptor (GBI) test assets are limited until the NGI program progresses to the point of manufacturing test articles, making annual flight tests of GMD infeasible. The MDA completed a test strategy, in consultation with DOT&E, to allocate GBI hardware to the operational inventory, operational spares, the Stockpile Reliability Program, and flight test.
- GMD modeling and simulation (M&S) continues to improve, but remains insufficient to support quantitative effectiveness and lethality assessments.

System

The GMD weapon system uses GBIs to defeat threat missiles during the midcourse segment of flight. Enabling the GBIs is a Ground System (GS) consisting of Ground Fire Control (GFC) nodes, an LMS, and In Flight Interceptor Communication System Data Terminals (IDT), all supported on the GMD Communications Network (GCN).

Mission

Commanders of U.S. Strategic Command and U.S. Northern Command employing U.S. Army Space and Missile Defense Command soldiers use the GMD system to defend the U.S. Homeland against IRBM and ICBM attacks.

Major Contractors

- GMD Integration: The Boeing Company – Huntsville, Alabama
- Boost Vehicle: Northrop Grumman Corporation – Chandler, Arizona
- Exo-atmospheric Kill Vehicle: Raytheon Technologies Corporation – Tucson, Arizona
- GFC, LMS, and GCN: Northrop Grumman Corporation – Huntsville, Alabama
- IDT: L3 Harris Technologies – Melbourne, Florida

Activity

- The MDA conducted testing in accordance with the DOT&E-approved Integrated Master Test Plan as affected by the coronavirus (COVID-19) pandemic, which caused the MDA to delay several test events and some programmatic milestones; for example:
  - The FY20 GMD ground test was executed prior to the pandemic, the developmental cybersecurity test was delayed approximately 1 quarter, and the live fire tests were moved to the end of this fiscal year.
  - To date, the single FY21 GMD flight test has been delayed 3 quarters and the GMD ground tests have slipped 1-2 quarters each.
- In FY20, the MDA conducted one ground test, one developmental cybersecurity test, and three lethality tests in which GMD was the major participant:
  - From November to December 2019, the MDA conducted a ground test of legacy Homeland Defense upgrades in support of the fielding of CE-I and CE-II EKV upgrades.
  - The MDA conducted a GS 8 Cybersecurity Table Top Exercise in July 2020.
  - In October 2019, the MDA conducted the last three GBI subscale light-gas-gun tests in a series of seven to anchor the lethality model for an ICBM threat. The MDA executed the first four tests in the series in 4QFY19.

- The MDA fielded:
  - GFC 7A.0.2 Phase II software with updates to Sea-Based X-band radar cueing and Target Object Map optimization, and CE-II 10.2 software with updates to salvo tracking, terminal aimpoint selection, threat databases, terminal artifact mitigation, and Target Object Map optimization in November 2019.
  - LMS software 7A.0.1.2 to support upgrades to the GBI Maintenance Manager in January 2020.
  - CE-I EKV software 23.2 providing the equivalent functionality already incorporated into CE-II EKV 10.2 to the legacy GBIs in July 2020.
- The GMD program continues to evolve:
  - The MDA approved a revised GMD Life Cycle Sustainment Plan in December 2019 to maintain a sustainment and repair capability for the fielded GMD weapon system and future capabilities.
  - The MDA released a Request for Proposal for the NGI in April 2020 and received multiple proposals from Industry in August 2020. The MDA is currently assessing these proposals.
  - In FY20, the MDA continued with construction and equipment manufacturing for Missile Field-4 at Fort Greely, Alaska, installed Launch Site Components for units 1-12, and completed Silo/Silo Interface Vault foundations 13-20.

Assessment

- The GMD weapon system has demonstrated capability to defend the U.S. Homeland from a small number of IRBM or ICBM threats (greater than 3,000 km range) with simple countermeasures when the Homeland Defense BMDS employs its full architecture of sensors/command and control. This assessment is unchanged from last year's annual report.
- During FY20 testing, the MDA collected data supporting development and fielding of new capabilities associated with GMD Capability Increment 6B. Test data and resulting assessments are classified; see the DOT&E "FY20 Assessment of the BMDS," to be published in February 2021.
- EKV lethality testing against emerging threats needs to continue in order to keep pace with threat evolution until the NGI is deployed, and to ensure the relevancy and accuracy of the M&S used in GBI lethality assessments.
- GBI test assets are limited until the NGI program progresses to the point of manufacturing test articles. In FY20, Congress provided $485 Million to the GMD program to begin reliability upgrades to the CE-I fleet, execute risk reduction activities, and procure additional Configuration 2 boost vehicles. Even so, annual flight tests of GMD, as required by the FY17 National Defense Authorization Act as amended, remain infeasible due to operational requirements. The MDA completed a test strategy to balance allocating GBI hardware to the operational inventory, operational spares, the Stockpile Reliability Program, and flight test. DOT&E participated in the development of and approved the resulting test strategy.
- GMD M&S continues to improve, but remains insufficient to support quantitative effectiveness and lethality assessments. Ground and flight test threat M&S for GMD lags behind current operationally realistic threats with respect to countermeasures, debris, raid sizes, and electronic attack.

Recommendations

The MDA should:

1. Address GMD M&S deficiencies to enable credible assessment against operationally relevant threats.
2. Continue light-gas-gun testing against emerging threats to anchor the development of EKV lethality models.

Aegis Ballistic Missile Defense (Aegis BMD)

Executive Summary

- The Aegis Ballistic Missile Defense (BMD) program participated in two non-intercept flight test events in FY20 with live ballistic missile targets and a hypersonic glide vehicle (HGV), one of which also exercised interoperability between U.S. and allied naval assets.
- Aegis BMD participated in two Ballistic Missile Defense System (BMDS) ground tests with hardware-in-the-loop (HWIL) and modeling and simulation (M&S) representations that provided data on Aegis BMD interoperability and weapon system functionality in various regional/theater and strategic scenarios.
- The Missile Defense Agency (MDA) delivered results from a subset of the high-fidelity M&S operational test runs for record for the Standard Missile (SM)-3 Block IIA missile. The MDA found errors in these M&S runs and is addressing the error. The data from these re-executed runs will support the DOT&E assessment of the operational effectiveness of the SM-3 Block IIA missile in FY21.
- The MDA conducted Flight Test Aegis Weapon System (FTM)-44 in November 2020, where an Aegis destroyer intercepted an intercontinental ballistic missile (ICBM) target with an SM-3 Block IIA missile using Aegis BMD's engage-on-remote capability. DOT&E will report the results of this flight test in a separate report.

System

- Aegis BMD uses SM-3 guided missiles to intercept ballistic missile threats outside the Earth's atmosphere, and uses SM-2 or SM-6 guided missiles to intercept ballistic missile and anti-air warfare threats within the atmosphere using Sea-Based Terminal (SBT) and self-defense capabilities. In addition to guided missile engagement support, the ship-based AN/SPY-1 radar provides long-range surveillance and track functions to support other BMDS elements.


Aegis Cruiser


Aegis Ashore and Vertical Launch System

- The Navy is developing the AN/SPY-6 Air and Missile Defense Radar for future Aegis destroyers to provide increased radar sensitivity, extended detection ranges, and simultaneous sensor support of ballistic missile and air defense functions.

Mission

Combatant Commanders will employ the Aegis BMD weapon system (sea- and land-based variants) to defend deployed forces and allies from short- to intermediate-range ballistic missile threats, and to provide forward-deployed sensor capabilities.

Major Contractors

- Aegis Weapon System: Lockheed Martin Corporation, Rotary and Mission Systems – Moorestown, New Jersey
- AN/SPY-1 Radar: Lockheed Martin Corporation, Rotary and Mission Systems – Moorestown, New Jersey
- SM-3, SM-2 Block IV, and SM-6 Missiles: Raytheon Missiles and Defense Company – Tucson, Arizona
- AN/SPY-6(V)1 Radar: Raytheon Missiles and Defense Company – Tewksbury, Massachusetts

Activity

- The MDA conducted testing in accordance with the DOT&E-approved BMDS Integrated Master Test Plan.
- The coronavirus (COVID-19) pandemic caused a 6 month or greater delay to Aegis BMD's first ICBM intercept attempt, FTM-44, and to the first SBT Increment 2 flight test in BMD Initialized mode, FTM-31 Event 1 (E1). The MDA conducted FTM-44 in November 2020 and plans to conduct FTM-31 E1 in April 2021.
- Aegis BMD participated in two non–intercept flight test events in FY20 with live ballistic missile targets and an HGV.
  - During Flight Test Experimental Other (FEX)-01 in March 2020, an Aegis BMD destroyer engaged an HGV with a simulated SM-6 Dual II missile. The AN/SPY-6(V)1 Radar participated in the event.
  - During the Pacific Dragon – 2020 Navy fleet exercise in August 2020, an Aegis destroyer engaged a short-range ballistic missile (SRBM) with a simulated SM-3 Block IB Threat Upgrade missile. Both ship and Aegis Ashore Missile Defense Test Complex (AAMDTC) detected and tracked the SRBM and reported data to the BMDS.
- In FY20, two BMDS ground tests involving HWIL and M&S representations of Aegis BMD provided information on interoperability and weapon system functionality in various regional/theater and strategic scenarios. The BMDS Operational Test Agency and the Navy Commander, Operational Test and Evaluation Force (COMOPTEVFOR) accredited the participating M&S used in the ground tests.

- The MDA executed and delivered a subset of the required high-fidelity M&S operational test runs for record for the SM-3 Block IIA missile in August 2020. The MDA expects to deliver the remaining runs for record throughout FY21.
- Budgetary reductions may result in a 2- to 3-year delay in Aegis Baseline 10 and AN/SPY-6(V)1 Integrated Air and Missile Defense flight test events, from FY24-25 to FY26-28. Furthermore, new test limitations will substantially reduce the operational realism of AN/SPY-6(V)1 electronic protection testing.
- The MDA is updating the Advanced Radar Development Evaluation Laboratory with an Aegis Baseline 10 virtual test environment that will connect to an in-place AN/SPY-6 engineering development model array. The update is planned to be completed and ready to test in 1QFY21.

Assessment

- Aegis BMD continues to demonstrate a capability to intercept non-separating, simple-separating, and complex-separating ballistic missiles in the midcourse phase of flight with SM-3 missiles. Aegis BMD has also demonstrated a capability to intercept select ballistic missiles in the terminal phase of flight with SM-6 missiles. However, flight testing and M&S have not addressed all expected threat types, ground ranges, and raid sizes. The MDA has used M&S to explore Aegis BMD raid engagement performance, but DOT&E has less confidence in these results because COMOPTEVFOR has been unable to accredit the models due to the lack of validation data from live fire raid engagements and lack of post-intercept debris modeling.
- During Pacific Dragon – 2020, the MDA demonstrated Aegis BMD interoperability with Republic of Korea naval assets while conducting simulated ballistic missile engagements. The AAMDTC demonstrated Aegis interoperability with Australian naval assets while tracking ballistic missile targets.
- DOT&E will provide an assessment of the FTM-44 test results and of the SBT Increment 2 capability (based on the results of FTM-31 E1 and FTM-33) in separate reports.
- MDA ground tests have routinely shown that inter-element coordination and interoperability need improvement to improve engagement efficiency; however, flight testing with multi-element engagement coordination has been limited. Aegis BMD has exercised rudimentary engagement coordination with Terminal High-Altitude Area Defense firing units, but not with Patriot. The MDA plans to exercise engagement coordination between those three theater elements during Flight Test Operational (FTO)-05, but that flight test has been repeatedly delayed and is currently planned for FY28.
- DOT&E and USD(R&E) have prompted the MDA to establish a ground testing approach to support assessments of missile reliability. DOT&E cannot assess SM-3 missile reliability with confidence until the MDA is able to provide additional ground test data that simulate the in-flight environment.
- The MDA delivered results from a subset of the high-fidelity M&S operational test runs for record for the SM-3 IIA missile. The MDA found a problem in one of the models used to conduct the M&S runs. The MDA has identified a fix action and the test runs will be re-run and delivered in FY21. The data from these re-executed runs will support the DOT&E assessment of the operational effectiveness of the SM-3 Block IIA missile in FY21.
- COVID-19 impacts have delayed delivery of high-fidelity M&S operational test runs for record to support an assessment of SBT Increment 2 operational effectiveness. Verification and validation data from flight testing will not be available until FY21 to support model accreditation. M&S operational test runs for record will not be available until FY22.
- The developmental AN/SPY-6(V)1 radar continues to track ballistic missiles during MDA flight tests. The radar detected and tracked the HGV target in FEX-01.

Recommendations

The MDA should:

1. Prioritize resources for FTO-05 to ensure this critical flight test occurs as soon as possible.
2. Conduct Aegis BMD midcourse and terminal phase flight testing with live fire intercepts of raids of two or more ballistic missile targets to aid in the validation of M&S tools.
3. Improve Aegis BMD high-fidelity M&S tools to incorporate post-intercept debris modeling to better assess engagement performance in raid scenarios.
4. Provide data from high-fidelity ground tests to DOT&E to inform SM-3 Block IB Threat Upgrade and Block IIA missile reliability estimates.
5. Work with DOT&E and USD(R&E) to establish a ground testing approach to support assessments of missile reliability.

Terminal High-Altitude Area Defense (THAAD)

Executive Summary

- The Missile Defense Agency (MDA) conducted two developmental flight tests of Patriot's ability to engage a short-range ballistic missile target using remote track and discrimination data from the Terminal High-Altitude Area Defense (THAAD) system in 2020. Both tests demonstrated THAAD's ability to provide remote track and discrimination data to Patriot.
- THAAD participated in three Ballistic Missile Defense System (BMDS) ground tests, providing information on THAAD functionality and interoperability.

System

The THAAD weapon system consists of a THAAD Fire Control and Communications (TFCC) module, an Army Navy/Transportable Radar Surveillance-2 (AN/TPY-2) Radar in Terminal Mode (TM), interceptors, launchers, and peculiar support equipment. For extended engagements, THAAD can provide or accept target tracking and discrimination data from Aegis Ballistic Missile Defense (BMD) ships or other sensors via the Command and Control, Battle Management, and Communications element. THAAD complements the upper-tier Aegis BMD and the lower-tier Patriot weapon systems.

Mission

Combatant Commanders in U.S. Indo-Pacific Command (USINDOPACOM), U.S. European Command (USEUCOM), U.S. Northern Command (USNORTHCOM), and U.S. Central Command (USCENTCOM) use the THAAD weapon system to defend deployed forces and allies from short- to intermediate-range ballistic missile threats in both the exo- and endo-atmosphere.

Major Contractors

- Prime: Lockheed Martin Corporation, Missiles and Fire Control – Dallas, Texas
- Interceptors: Lockheed Martin Corporation, Missiles and Fire Control – Troy, Alabama
- AN/TPY-2 (TM) Radar: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts

Activity

- The MDA conducted testing in accordance with the DOT&E-approved Integrated Master Test Plan.
- THAAD participated in three BMDS-level integrated ground tests, providing information on THAAD functionality and interoperability in regional/theater scenarios. The coronavirus (COVID-19) pandemic delayed execution of the June 2020 integrated ground test event and the February 2020 integrated ground test analysis.
- The MDA conducted Ground Test Integrated (GTI)-07c in December 2019, to examine USINDOPACOM defense using THAAD 3.2 (TH 3.2) software.
- The MDA planned to conduct GTI-20, Sprint-2 to examine USINDOPACOM defense using TH 3.2 software in March 2020, but it was delayed until June 2020 partially due to COVID-19 restrictions and partially due to Patriot model readiness.
- The Army conducted Developmental Test Flight Test Other (FTX)-39 in October 2019 using Patriot Post-Deployment Build-8.0.6 software to demonstrate a simulated engagement against a short-range ballistic missile (SRBM) to test Patriot's capability to launch on THAAD data. The Army declared FTX-39 a no-test when the test target went off course soon after launch and range safety destroyed the target prior to the THAAD radar acquiring it.
- In February 2020, the MDA examined USEUCOM and USCENTCOM defense using TH 3.2 software. COVID-19 restrictions delayed analysis results by approximately 4 months.

- The MDA and the Army conducted Flight Test Patriot Weapon System-27 Event 2 (FTP-27 E2) in February 2020 and FTP-27 Event 1 (FTP-27 E1) in October 2020 at White Sands Missile Range, New Mexico. FTP-27 E2 and FTP-27 E1 were developmental flight tests of Patriot's ability to engage a short-range ballistic missile target using track and discrimination data from THAAD. In both tests, the THAAD battery consisted of THAAD Configuration 2 hardware, TH 3.2 software, TFCC, and an AN/TPY-2 (TM) radar.
- The MDA is planning a developmental flight test and a developmental/operational flight test in 2QFY21 with THAAD 4.0 organically integrating and firing Patriot Missile Segment Enhancement (MSE) interceptors to demonstrate initial THAAD-MSE integration.
- The MDA and the Army did not execute dedicated operational flight testing of Patriot's ability to launch on track and discrimination data from THAAD as planned in FY20. The MDA and Army plan to conduct a developmental/operational flight test to demonstrate THAAD-MSE integration in March 2021.

Assessment

- During integrated ground tests, the MDA demonstrated aspects of THAAD functionality in different theater scenarios to support an urgent materiel release and BMDS Increments 5B, 5C, and 6B.1. Details are classified; see the DOT&E "FY20 Assessment of the BMDS" report to be published in February 2021.
- In FTP-27 E2, THAAD tracked and discriminated the target and sent the track data to Patriot over tactical networks. Patriot launched two interceptors based on THAAD data, but the interceptors failed to intercept the target. The Army determined that the missed intercept was unrelated to THAAD integration (see the Patriot article on page 221 for more details). The MDA and the Army delayed the follow-on test, FTP-27 E1, until October 2020 to allow time for FTP-27 E2 failure analysis and to verify fixes.
- In FTP-27 E1, THAAD tracked and discriminated the target and sent the track data to Patriot. Patriot launched two interceptors based on THAAD data and successfully intercepted the target.
- Developmental flight testing in FY20 did not fully address suitability shortfalls that DOT&E previously reported, including training and documentation deficiencies.

Recommendations

The MDA and the Army should:

1. Conduct dedicated operational flight testing of all new capabilities, including the Patriot launch-on-remote capability, to assess THAAD's effectiveness, interoperability, and engagement coordination with the full BMDS architecture as it evolves.
2. Continue to improve the quality of THAAD training and documentation and incorporate their delivery to THAAD soldiers through the Army training and publication processes.

Patriot Advanced Capability-3 (PAC-3)

Executive Summary

- The coronavirus (COVID-19) pandemic delayed the start of the Post-Deployment Build (PDB)-8.1 Developmental Test and Evaluation from June 2020 to a projected date of March 2021, and the PDB-8.1 Limited User Test (LUT) from June 2021 to a projected date of March 2022.
- The Missile Defense Agency (MDA) and the Army conducted Flight Test Patriot Weapon System (FTP)-27 Event 2 (E2) in February 2020 to test Patriot's capability to launch on Terminal High-Altitude Area Defense (THAAD) data.
- The MDA and the Army successfully conducted FTP-27 E1 in October 2020 to demonstrate an extended ground range intercept exercising Patriot launch on remote (LOR) using THAAD data.

System

The Patriot weapon system is a mobile air and missile defense system that includes C-band phased-array radars for detecting, tracking, classifying, identifying, and discriminating targets; battalion and battery battle management elements; and a mix of the Patriot Advanced Capability (PAC)-3 and Missile Segment Enhancement (MSE) hit-to-kill interceptors and PAC-2 blast fragmentation warhead interceptors for negating missile and aircraft threats.

Mission

Combatant Commanders use the Patriot system to defend deployed forces and critical assets (point defense) from missile and aircraft attack and to defeat enemy surveillance air assets in all weather conditions.

Major Contractors

- Prime: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts (ground system and Patriot Advanced Capability-2 and prior generation interceptor variants)
- PAC-3 and MSE interceptors and PAC-3 Command and Launch System: Lockheed Martin Corporation, Missile and Fire Control – Grand Prairie, Texas

Activity

- The Army conducted a cybersecurity assessment in April 2019 that focused on Internet Protocol interfaces. Non-Internet Protocol interfaces have not yet been evaluated.
- The Army conducted flight testing in accordance with the DOT&E-approved Patriot System Test and Evaluation Master Plan, and the MDA conducted testing in accordance with the DOT&E-approved Integrated Master Test Plan, as affected by the COVID-19 pandemic.
- The MDA and Army conducted Developmental Test Flight Test Other (FTX)-39 in October 2019 using PDB-8.0.6 software to demonstrate a simulated engagement against a short-range ballistic missile (SRBM) to test Patriot's capability to launch on THAAD data.
- The COVID-19 pandemic delayed the start of the PDB-8.1 Developmental Test and Evaluation from June 2020 to a projected date of March 2021. The Army had intended to start the next Patriot operational test, the PDB-8.1 LUT, in June 2021, but it rescheduled the LUT to start in March 2022.
- The MDA and the Army conducted FTP-27 E2 in February 2020 at White Sands Missile Range, New Mexico. During this developmental flight test, THAAD detected and tracked an SRBM target and passed data to Patriot, which launched two MSE interceptors on remote track data at the target.
- The MDA conducted Ground Test Integrated (GTI)-20 Sprint 2 in June 2020 to examine potential Patriot MSE launch-on-THAAD capabilities within the Ballistic Missile Defense System architecture.
- The Army corrected their missile software update process and demonstrated the corrected process in preparations for a Qatar Foreign Military Sales program flight tests in June 2020, and FTP-27 E1 in October 2020. Preflight ground testing

procedures have been updated to detect any similar errors in the future.
- The MDA and Army conducted developmental flight test FTP-27 E1 in October 2020 at White Sands Missile Range, New Mexico, to demonstrate Patriot LOR capability.

Assessment
- The MDA and Army declared FTX-39 a no-test when the test target went off course soon after launch and range safety destroyed the target prior to the THAAD radar acquiring it. The MDA and Army intended to track the target using a THAAD radar and pass that data to Patriot, but not launch MSE interceptors, as a risk reduction test event.
- The MSE seekers in FTP-27 E2 did not enter target acquisition during endgame, which resulted in both interceptors missing the target. The cause of this failure was an error in a new missile software update process that the Army used for the first time. Pre-flight laboratory runs did not discover the error because those runs used a different missile software update process.
- GTI-20 Sprint 2 represented Patriot with the Battalion Simulation (BnSim). The Army was still developing BnSim at the time of test execution. The operational testers concluded that BnSim currently lacks sufficient maturity to meet operational test requirements and enable performance assessments during MDA ground tests. As a result, the operational testers considered GTI-20 Sprint 2 a developmental test. The testers were able to collect limited developmental data for the Patriot LOR capability. Patriot M&S continues to develop and improve, but remains insufficient to support quantitative effectiveness and lethality assessments.
- During FTP-27 E1, THAAD detected and tracked an SRBM target and passed the tracking data to Patriot. Patriot launched two MSE interceptors. Patriot successfully intercepted the target using the remote track data to achieve an extended ground range engagement.

Recommendations

The Army should:
1. Assess the Patriot radar and other non-Internet Protocol-based systems, such as the launchers and Antenna Mast Group during the PBD 8.1 LUT.
2. Continue to develop/improve BnSim to eliminate the current shortfall and support ground testing needs.

Live Fire Test and Evaluation

Live Fire Test and Evaluation

Live Fire Test and Evaluation

EXECUTIVE SUMMARY

- In FY20, DOT&E executed LFT&E oversight for 84 Service acquisition programs designed to field DOD technologies, 3 joint programs, and 2 special interest programs.
- In support of fielding DOD technologies, DOT&E published three combined OT&E and LFT&E reports summarizing the survivability and lethality performance of subject systems and offered recommendations to further advance their performance in emerging combat environments.
- In accordance with the National Defense Strategy, DOT&E continued to focus the objectives of the three joint programs to:
  - Deliver and maintain credible joint weaponeering tools capable of providing weapons or mission effect estimates across all warfare domains.
  - Deliver T&E tools and joint aircraft survivability solutions to assess and mitigate U.S. aircraft losses in projected combat missions and areas of operation.
  - Innovate T&E methods to include modeling and simulation (M&S) tools to support efficient prototyping and fielding of DOD technologies.
- DOT&E provided oversight of two special interest projects focused on (1) delivering credible evaluations of combat-induced injuries and (2) collecting adequate combat damage data.

ACQUISITION PROGRAMS

In FY20, DOT&E executed LFT&E oversight for 84 acquisition programs and published 3 combined OT&E and LFT&E reports. These reports provided assessments of the survivability and lethality performance of subject systems and offered recommendations to further advance their performance in emerging combat environments.

- "Abrams M1A2 System Enhancement Package Version 2 (SEPv2) with Trophy Active Protection System Early Fielding Report," published in June 2020, assessed the enhanced survivability of the Abrams M1A2 tank when fitted with Trophy. The report supported the Army's decision for Urgent Material Release of the Enhancement Package to four brigades in Europe and the Pacific.
- "Small Diameter Bomb (SDB) II Early Fielding Report/Phase I Combined Operational Test and Live Fire Test Report," published in July 2020, assessed the SDB's preparedness for fielding on the F-15E aircraft. The report supported the United States Air Force Air Combat Command's authorization for fielding of SDB II on the F-15E.
- "Joint Air to Ground Missile (JAGM) Operational Assessment," published in August 2020, detailed the integration and performance of the JAGM missile on the Army's helicopter platform. JAGM was found to be as lethal as the legacy HELLFIRE missile while also delivering additional operational capability.

JOINT PROGRAM CHARTERS

LFT&E provides oversight of three programs chartered to support LFT&E title 10 requirements and operational needs. A brief description of these programs is below. Given their common objectives, they will be referred to in this report as joint programs.

Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME)

JTCG/ME serves as the DOD's sole developer of joint weaponeering tools known as Joint Munition Effectiveness Manuals (JMEMs). JMEM products include weaponeering tools capable of estimating the appropriate number and types of weapons required by Combatant Commands (CCMDs) to achieve the desired lethal effect on a target while also mitigating risk for collateral damage (reduce civilian casualties). As such, JMEMs rely on:

- Credible and authoritative data to accurately capture the performance of DOD weapons against relevant, adversary targets.
- Accredited physics-based models and analytical methods to estimate DOD weapons effects for a wide range of relevant engagement conditions.
- User-friendly and secure software that permits mission planners to predict and visualize weapons effects, while also estimating the potential for civilian casualties.

DOT&E provides oversight and strategic guidance to JTCG/ME to support the development of credible and operationally relevant JMEM products as the complexities of the operational environment emerge. The Army's Combat Capability Development Command Data and Analysis Center executes the JTCG/ME mission in accordance with DOT&E guidance, Joint Staff Military Targeting Committee requirements, and Chairman of the Joint Chiefs of Staff Instructions. Current JMEM products include:

1. Digital Imagery Exploitation Engine used to first geographically locate and characterize the target (using National Geospatial-Intelligence Agency tools), then weaponeer the target using JMEM Weaponeering Software, and lastly, estimate collateral damage effects using the Digital Precision Strike Suite Collateral Damage Estimation tool.
2. Joint Anti-Air Combat Effectiveness tool used in combat mission planning, training, and in weapon schools to support the development of air combat tactics, techniques, and procedures.
3. Reach-back analysis packages and reports to directly assist CCMDs and to meet the urgent operational requirements of a dynamic environment (e.g., rapid development of probability of kill data and collateral damage estimates for emerging weapons or targets).

To maintain relevancy in multi-domain combat environments, DOT&E continues to emphasize the need and support for the development of JMEM products capable of estimating lethal effects for cyber, electromagnetic spectrum fires (EMS), and directed energy weapons. Most recent efforts included accreditation of the first Cyber JMEM increment, further advancement of the development of the first Directed Energy Weapons JMEM that included the initiation of a JMEM for High Power Microwaves (HPM), and initiation of the development of the EMS Fires JMEM. Additional resources are required to incorporate the effects of U.S. and adversary countermeasures across JMEM products.

Joint Aircraft Survivability Program (JASP)

JASP serves as the DOD lead in enabling the development of cross-Service aircraft survivability solutions and evaluation methods needed to mitigate operational shortfalls of U.S. aircraft in combat. JASP responds to the existing and emerging multi-domain operating environments and provides solutions to prevent U.S. aircraft losses to either kinetic or non-kinetic engagements. JASP is the only program in the Department positioned to enable the coordination and support for:

- Development of joint M&S tools and capabilities needed to evaluate and advance aircraft survivability as required by title 10, and for use by CCMDs and Service aviation weapons and tactics squadrons, schools, or training ranges for mission planning and combat operations.
- The Joint Combat Assessment Team (JCAT) to collect and analyze U.S. aircraft combat damage and losses. These data and combat reports have been critical in informing title 10 aircraft survivability evaluations and in highlighting the requirements for joint aircraft survivability solutions to provide force protection and remedy operational shortfalls.

JASP is chartered by the aviation components of each Service: the Naval Air Systems Command, the Air Force Life Cycle Management Center, and the Assistant Secretary of the Army for Acquisition, Logistics and Technology. The Services provide the manpower and funds while DOT&E provides stability in funding and strategic guidance for JASP to meet DOD needs.

Joint Live Fire (JLF) Program

JLF program supports LFT&E execution of title 10 responsibilities by addressing a more comprehensive spectrum of survivability and lethality problems as both the complexity of our own technologies and the operational environment advance. The JLF program has been chartered to address two-overarching concerns: (1) survivability/lethality performance shortfalls of deployed DOD systems due to changes in either concepts of operations, systems' mission, rules of engagement, or the emerging threat environment; and (2) survivability/lethality test and evaluation capability shortfalls due to the increased complexity of either DOD systems or adversary threats.

LFT&E JOINT PROGRAM ACCOMPLISHMENTS

BUILD A MORE LETHAL FORCE

In FY20, DOT&E monitored the implementation of updates to current JMEM products designed to estimate lethal and collateral damage effects for kinetic energy weapons. The following updates improved mission planning efficiency, credibility, and analytical support to CCMDs responsible for targeting high-value assets:

- Enhanced Digital Imagery Exploitation Engine to enable greater interoperability of targeting capabilities across the Department.
- New JMEM software design features including effects data libraries to enable more rapid characterization of the adversary target and features that improve connectivity to targeting and mission planning systems.
- Updates to the integrated weapon/target data and damage effects data sets to account for additional weapons in the U.S. inventory for use by the targeting community.
- Updates to Collateral Effects Radii Reference Tables in accordance with Chairman of the Joint Chiefs of Staff Instruction (within the context of Theater Rules of Engagement and the Laws of Armed Conflict) to further mitigate risk to non-combatants during weapons employment.

- Improved collection and analysis of Battle Damage Assessment data post-strike to support validation and confidence of existing weaponeering tools. These efforts leverage digital engineering processes to provide efficiencies and increased data availability to the operational and acquisition communities. Detailed analysis of combat data will optimize munition expenditure rates and will ultimately mitigate stockpile stress.

Although DOT&E continues to enhance the support to JTCG/ME to meet emerging operational needs, additional resources are necessary to update JMEM products to more accurately represent kinetic energy weapon effects in the operational environment. For example, current JMEM tools do not account for emerging capabilities, such as hypersonics as well as the expanding survivability enhancement technologies (e.g., countermeasures, decoys, electromagnetic spectrum management). Current JMEM tools must also include advanced capabilities for maritime targets based on CCMD urgent needs.

In FY20, DOT&E supported the development of four new JMEM tools required to enable multi-domain operations:

- **Cyber Operation Lethality and Effectiveness (COLE) tool.** The COLE tool provides an analytical engine intended to support offensive cyber operations. It provides the means to develop and characterize the target's cyberspace (network and its environment) offering visualization tools to cyber operators previously not available although additional resources are required to automate the development of the network. The COLE tool also enables easy access to a range of weapon and target characterization needed to plan the attack although additional efforts are in place to automate access and ingestion of all available data. Lastly, the COLE tool includes fundamental analytical tools that need to be further advanced to enable effects estimates for a sequence of cyberattacks in the absence of empirical data.
- **Directed Energy Weapons JMEMs.** The Directed Energy Weapons JMEMs will enable targeteers to incorporate High Energy Laser (HEL) and HPM Weapon Systems into the Joint Targeting Cycle:
  - **Joint Laser Weaponeering Software (JLaWS) tool.** The tool is founded on test data collected to verify and validate available M&S tools and to characterize the vulnerability of a subset of operationally relevant targets to high-energy lasers. The tool enables target damage and collateral damage effect estimates unique to directed energy weapons. JTCG/ME is executing a multi-year test and methodology development plan to continue to update this tool with data needed to accurately capture existing and emerging U.S. high-energy laser performance as a function of system power, dwell time, jitter, and other factors needed to validate and operationalize this tool.
  - **High Power Microwave (HPM) Weaponeering tool.** JTCG/ME developed a multiyear test and methodology development plan, which is adequate to underpin data standards and enhance currently available effectiveness and collateral risk estimate methods needed for the development of an HPM weaponeering tool.
- **Electromagnetic Spectrum (EMS) Fires JMEM.** JTCG/ME initiated a new EMS Fires JMEM effort to enable the mission planners and targeteers to: (1) assess the effectiveness of our weapons (specifically the guidance system) in the presence of adversary-induced electromagnetic spectrum effects (e.g., GPS denial); and (2) assess the effectiveness of our own electromagnetic spectrum effects on adversary targets. In FY20, JTCG/ME collected and evaluated operational requirements and started the development of data standards for EMS Fires effects. JTCG/ME also conducted a DOD-wide review of available analytical tools, models, and data sources, to include GPS analytical services that could be used a foundation for the EMS Fires JMEM. These initial tasks intend to leverage and optimize existing Service/Intelligence-based models and data capabilities for efficiency.

In FY20, DOT&E monitored the execution of several efforts that improved air combat lethality and survivability:

- Updates to the Joint Air Combat Effectiveness tools (J-ACE)/Joint Anti-Air Model (JAAM) tool to include implementation of new threat weapons, improved aircraft aero performance and blue air-to-air missile models, and increased validation with test and training range data. J-ACE/JAAM tools estimate air-to-air/surface-to-air combat effectiveness to support air combat tactics, techniques, and procedures development at national test and training ranges. JTCG/ME and JASP continued to develop the next generation J-ACE/JAAM product line founded on a modular architecture and the effects data library with an added capability that also considers rotorcraft platforms with their respective countermeasures.
- Flight testing that demonstrated the effectiveness of a new RF-countermeasure technique to improve the survivability of U.S. aircraft against a class of advanced surveillance radar systems and flight testing that demonstrated the ability of U.S. countermeasures systems to defeat a near-peer electro-optical/infrared (EO/IR)-guided threat system.
- Development of a low size, weight, and power active electronically scanned array to enable effective radio frequency countermeasures (RFCM) capabilities for the DOD vertical lift fleet.
- Collection and analysis of data to identify trends in helicopter combat-related injuries, demonstration of aircraft hardening solutions against high energy laser threats, and development of novel fuel tank solutions to mitigate fire-induced helicopter losses.

In FY20, the Joint Live Fire program addressed several contemporary survivability and force protection problems:

- Development of a new metric to more adequately characterize the behind armor blunt trauma imparted on our joint force by combat-induced, hard armor deformation. This effort will determine if the dynamic deformation rate, not simply deformation depth, is a potential factor that needs to be considered in future body armor test and evaluation programs.

- Development of a test fixture for use in evaluation of failure criteria of structural components due to internal blast. This test fixture will be used to improve current failure criteria, and the resulting data incorporated into the Advanced Survivability Assessment Program (ASAP) model to be leveraged by naval platform LFT&E programs.
- Development of detailed dataset characterizing titanium fragment penetration, breakup, and flight dynamics through complex target geometries representing steel and aluminum naval ship construction. The experimental data will be compared to M&S predictions to provide improved confidence in the tri-Service/DOD fragment penetration code used in all lethality and survivability evaluations.

STRENGTHEN ALLIANCES AND BUILD NEW PARTNERS

In FY20, DOT&E strengthened alliances by supporting multiple efforts with coalition partners. Specifically:

- Supported the delivery of weaponeering tools/data sets and training to coalition partners in support of current operations under Foreign Military Sales agreements. This included the release of weapon effectiveness tables, Collateral Effects Radii tables, and advanced target development capabilities to key coalition partners to minimize collateral damage/reduce civilian casualties. These efforts directly supported the Presidential Conventional Arms Control Policy to build partner capacity and prevent civilian casualties.
- Supported information exchange forums via information exchange agreements (IEAs) with several coalition partners. These exchanges facilitate collaboration on methodologies and efforts of mutual interest in the area of weapons effectiveness/collateral damage estimation.
- Supported standardization of weapon characteristics and interoperability by providing coalition partners with the updated JTCG/ME Weapon Test Procedures Manual, which will augment international test operation procedures.
- Supported the partnership with the Republic of Korea to develop a test capability to induce hydrodynamic ram loads in aircraft structural joints. This collaboration will develop test devices in the U.S. and the Republic of Korea, collect data for model verification, and enable more survivable aircraft structural designs.
- Supported urgent operational needs with rapid development of probability of kill data tables and collateral damage analysis packages for high-priority weapons and targets. These specialized products directly assist CCMDs to meet the operational requirements of a dynamic environment.

REFORM THE DEPARTMENT FOR GREATER PERFORMANCE AND AFFORDABILITY

In FY20, DOT&E managed the oversight of the joint programs to support Department reforms by advancing the state of the art M&S tools and other innovative T&E methods. These efforts continue to introduce efficiencies in LFT&E to support rapid prototyping and rapid fielding while minimizing risk to the warfighter.

New Weaponeering Tool Software Architecture to Enable Targeting Solutions across Warfare Domains

JTCG/ME implemented the use of a new software architecture for JMEM products. The new software will support modular capabilities and improved interface with all new data or methods, which will be stored in various Joint Effects Libraries. These libraries enforce data standardization and enable increased leveraging/sharing of data and models across the Services. This common foundation will increase efficiency and returns on investment for future M&S development. The development of these libraries also increases opportunities to utilize advanced data analytics, such as neural network tools, data compression algorithms (XGBoost), and machine learning. Use of these advanced analytical techniques will improve the quality of existing solutions, decrease computation time of applications, and answer questions previously not possible. Initial implementation efforts included establishing DevSecOps capabilities for Agile software development to reduce product fielding timelines.

Credible Modeling and Simulation (M&S) Tools to Increase Efficiency and Reduce Risk

DOT&E reprioritized the joint programs to focus on increasing the accuracy, credibility, and capability of M&S tools used in title 10 LFT&E evaluations and JMEM products. The efforts focused on baselining M&S tool capabilities and limitations, completing sensitivity studies to identify M&S factors that may drive the output errors, and formulating strategic roadmaps to increase the credibility and/or capability of these tools.

The three major M&S tools used to predict either system survivability or conversely the weapon lethality include the Army-managed Advanced Joint Effectiveness Model (AJEM), the Air Force-managed Computation of Vulnerable Area Tool (COVART), and the Navy-managed Advanced Survivability Assessment Program (ASAP). All three rely on two additional M&S tools: Fast Air Target Encounter Penetration (FATEPEN) model used for estimating penetration of warhead-generated fragments and Projectile Penetration (ProjPEN) used for estimating penetration of small- and medium-caliber projectiles. Two additional M&S tools are used to evaluate the engagement kill chain of adversary surface-to-air and air-to-air weapons against our aircraft: Enhanced Surface-to-Air Missile Simulation (ESAMS) and Brawler.

DOT&E facilitated a tri-Service model review summit to re-baseline the verification, validation, and accreditation (VV&A) process that will be used in re-accrediting these M&S tools. The intent was to characterize the error bounds and understand their root-cause so DOT&E can identify and address shortfalls in upcoming joint program builds. These efforts will ultimately accelerate the overall analysis process and enable the prioritization of test parameters during a T&E program.

- **Advanced Joint Effectiveness Model (AJEM)** estimates the lethality/vulnerability of ground combat vehicles, small boats, and aircraft to kinetic energy weapons. This first FY20 effort focused on increasing the capability of AJEM to model irregular fragments and highly yawed long rods effects as seen in more recent weapon designs. The second effort focused on rebaselining the VV&A processes used in AJEM to increase its credibility while lowering risk in title 10 evaluations. The third effort focused on an adequate transition of AJEM modules (e.g., Operational Requirements-based Casualty Assessment (ORCA) for personnel injury calculation) into previously mentioned Joint Effects Libraries that will serve as the foundation of future weaponeering tools.
- **Computation of Vulnerable Area Tool (COVART)** estimates aircraft vulnerabilities to kinetic energy weapons. This first FY20 effort included a statistical evaluation of the variation in vulnerability analyses due to known errors in the FATEPEN and ProjPen penetration models as well as variability in the threat data and the threat representation. The second effort focused on the integration of key capabilities from the Next Generation Fire Model into COVART to enable credible prediction of threat-induced fires onboard an aircraft. The third effort supported the validation of a rapid structural vulnerability assessment tool for the evaluation of the threat-induced, residual integrity of the systems' structure.
- **Advanced Survivability Assessment Program (ASAP)** predicts the vulnerability of ships to anti-ship weapons. FY20 efforts included verification and validation (V&V) review of ASAP using statistical measures and sensitivity studies. FY20 also included testing needed for validation of improvements to ASAP damage modules currently under development. DOT&E continues to work with the Navy to ensure that V&V of vulnerability assessment tools are adequate and appropriate to their use supporting LFT&E.
- **Fast Air Target Encounter Penetration (FATEPEN)** estimates warhead-generated fragment penetration against an array of operationally representative targets. FY20 efforts initiated the accreditation process to enable lethal effect estimates of highly yawed long rods formed by many contemporary munitions. In parallel, a tri-Service model review committee is completing a full re-accreditation of FATEPEN capabilities.
- **Projectile Penetration (ProjPEN)** estimates projectile penetration against an array of operationally representative targets. FY20 efforts continued to support a parametric study to evaluate the model estimate errors and their root cause. In addition, FY20 efforts included updates to FATEPEN and ProjPEN graphical user interfaces to ensure compliance with current operating systems and to enable data exchanges between FATEPEN and ProjPEN for improved efficiencies.
- **Enhanced Surface-to-Air Missile Simulation (ESAMS)** estimates the probability of engagement of U.S. aircraft by radar-directed, surface-to-air missile systems. FY20 efforts included updates to high-priority missile threat representations that included the latest aerodynamic performance data provided by the Intelligence Community. FY20 efforts also focused on increasing ESAMS capability to assess rotorcraft susceptibility to RF-guided, surface-to-air missile threats. This effort included the development of capabilities to accurately represent the platform's signature with the dynamic blade flash, as well as the effects of low altitude clutter. With ESAMS v5.7 set to be the last version openly distributed throughout the DOD and industry, FY20 efforts also supported the initial development of the Survivability and Lethality Assessments within a Tactical Engagement (SLATE), which shares the same architecture as the JTCG/ME assessment tool, JAAM. The initial version of SLATE, scheduled for release in FY22, will enable the evaluation of the susceptibility of rotorcraft and fixed-wing aircraft to air defense artillery utilizing National Ground Intelligence Center (NGIC) threat representations (Threat Modeling & Analysis Program (TMAP) models), surface-to-air missiles utilizing Missile and Space Intelligence Center and Office of Naval Intelligence TMAP models, and air-to-air missiles utilizing the National Air and Space Intelligence Center TMAP models.
- **Brawler** is an air-to-air engagement analysis tool. FY20 efforts addressed multiple user requested code enhancements including onboard and off-board sensor fusion, increased fidelity of the infrared (IR) environment, increased capability for passing tracks, and increased flexibility in the Brawler generated output files. Brawler supports technology development, analysis of alternatives, and title 10 evaluations.

Innovative T&E Methods

In FY20, DOT&E leveraged the joint programs to research and adapt best practices in industry, academia, and across government laboratories intended to introduce efficiencies in DOT&E processes and increase the credibility of DOT&E evaluations. Examples include:

- **Enhanced Weaponeering and Collateral Damage Effects.** Efforts focused on executing a multiyear test program designed to generate the data needed to enhance and validate current weaponeering and Collateral Damage Effects methodologies as required by Strike Approval Authorities. Testing supported the evaluation of the effects of the ordnance burial medium and the ordnance type on crater ejecta and collateral damage, as well as characterization of building debris to be used by pertinent M&S tools.
- **Data Analytics.** Effort leveraged the expertise at Sandia National Laboratories to capture three-dimensional (3D) tracking warhead fragmentation to enable multi-sensor data fusion for improved warhead characterization and weaponeering solutions. This effort improves the lethality assessment metrics by applying the data to validate relevant M&S tools to establish uncertainty quantification estimates for fragment position, velocity, mass, count, and drag. Application of artificial intelligence techniques, high-speed stereoscopic optical, and x-ray development included in this effort are intended to reduce the number of weapon test articles and labor-intensive activities in future weapon lethality T&E programs.

- **Scalable Test Methods.** Efforts leveraged the expertise at the Air Force Research Laboratory Munitions Directorate to enable the use of scalable experimentation methods in LFT&E. Air Force designed and manufactured a building at 1/9th-scale and executed 42 airblast experiments of operationally relevant weaponeering scenarios. These data will be analyzed to quantify error bounds in JMEM airblast models. As new weapons and target sets materialize, JMEM developers will have a tailorable scale model they can use to validate blast effects models at a fraction of the cost.
- **Advanced Sensors**. Efforts focused on the development of a new sensor that has the ability to accurately measure high frequency and high amplitude motion produced during kinetic energy weapon-induced blast and shock tests. The team executed over 150 laboratory tests to incorporate the sensor suite in 5 Amphibious Combat Vehicle full-up system-level live fire tests. Follow-on analysis of the laboratory and vehicle test data will yield a configurable sensor suite with a supporting user manual and software package.
- **Threat Model Development.** Efforts focused on the development of an all-digital threat model that will allow for more expedient evaluation of IR countermeasure (IRCM) techniques. Similarly, updates to RF-guided threat radar models and the ESAMS signal environment will allow for more expedient development and evaluation of advanced electronic techniques and RFCM. In coordination with the NGIC, efforts also focused on the development of rocket-propelled grenade models and a stand-alone threat electronic warfare system TMAP model for integration into simulation environments. TMAP model will provide a more accurate representation of the electronic environment as it gets incorporated into the DOD/Intelligence Community's M&S framework, Integrated Threat Analysis & Simulation Environment.
- **IRCM Break-lock Test Accuracy.** Effort supported data collection from over 500 IRCM break-lock jam events to compare them with laboratory test data and improve the accuracy of current flight test effectiveness assessment methods.
- **Capability-Based Teaming System Analysis.** Effort leverages the expertise from Massachusetts Institute of Technology and their System Theoretic Process Analysis to support a development of a methodology intended to provide efficient and operationally relevant survivability and lethality evaluation of a system of systems. Capability is being demonstrated on a mission vignette, which includes a lead helicopter and several unmanned aerial vehicles coordinating on identifying and locating a target.
- **Machine Learning to Optimize Armor/Anti-Armor Performance.** Effort is focused on leveraging artificial intelligence and machine learning to optimize armor system designs and the evaluation of their effectiveness against a range of kinetic energy threats. The Army Research Laboratory in coordination with the Aberdeen Test & Evaluation Center is creating a robust scalable armor performance database for use by "to be" developed trained algorithms that can: (1) predict kinetic threat engagement outcomes at a fraction of the cost of a full-scale live-fire test, and (2) optimize armor and anti-armor solutions.
- **Engagement Model of Rotorcraft in an Electromagnetic Spectrum Contested Environment.** Effort is focused on an engagement simulation capability for rotorcraft capable of modeling rotorcraft flight dynamics, maneuvers, and RFCM techniques for the purposes of evaluating rotorcraft survivability. Effort focused on updating threat radars in ESAMS, collecting applicable RCS data for validation, integrating clutter tools, and building a pseudo rotorcraft 6 degrees of freedom flight model with reactive maneuvers. This capability will meet the requirements identified by the Army's Future Attack Reconnaissance Aircraft and Future Long-Range Assault Aircraft, as well as the Marine's Aviation Weapons and Tactics Squadron.
- **Active Protection System (APS) M&S** estimates the survivability of U.S. vehicles equipped with APS systems. FY20 efforts focused on improving the ability to model the APS end-to-end event sequence, focusing on intercept outcomes, residual characterization, and vulnerability of the platform and its crew.
- **Integrated Recoverability Model (IRM) and the Fire and Smoke Simulator (FSSIM)** module predicts the inception of fires, fire spread, and times to extinguish. FY20 efforts yielded incremental improvements model indirect firefighting, HVAC systems effect on smoke spread, fire spread via holing, and flooding effects on fire. Improvements will be incorporated to the models and leveraged by LFT&E programs for secondary effects analyses and recoverability assessments.
- **Total Mine Susceptibility System (TMSS) M&S** predicts the fire points for naval influence mines when interacting with ship underwater signatures. The Navy uses TMSS to predict the operational safe transit depths for U.S. Navy ships. The test data of the 2019, Littoral Combat Ship 11 Advanced Mine Simulator System (AMISS) trial showed poor statistical correlation between the predicted mine fire points from TMSS and the AMISS trial data. In FY20, DOT&E conducted a detailed assessment of the AMISS trial data to determine the root causes of the observed discrepancies. In FY21, DOT&E will engage the mine susceptibility experts from Naval Surface Warfare Center Panama City Division to resolve the identified issues and improve, if needed, the capabilities and accuracy of TMSS.

LFT&E SPECIAL INTEREST PROGRAMS

Warrior Injury Assessment Manikin (WIAMan)

WIAMan is a military-specific anthropomorphic test device (ATD) intended to evaluate injuries to ground combat vehicle occupants due to vertical accelerative loading typically observed in mine engagements. The WIAMan program consists of three main efforts:

- Development of the ATD with an integrated data acquisition system
- Biomechanics research to accurately characterize and predict the injury
- Finite element model of the WIAMan to support future M&S assessments

In FY20, the Army Combat Capabilities Development Command – Data and Analysis Center continued the biomechanics research to support the development of human injury probability curves and injury assessment reference curves. The Army completed the injury curves in 4QFY20. The Army also conducted and analyzed a series of whole body Post-Mortem Human Surrogates and ATD matched-pair experimental tests to support the validation effort of these curves but additional analyses are required to adequately accredit WIAMan for use in LFT&E. The Army intends to complete the VV&A efforts to use the WIAMan in FY21 during Armored Multi-Purpose Vehicle full-up system-level testing.

Combat Damage Assessment

JASP continued to enable adequate aircraft combat damage incident reporting and aviation combat injury analyses through the Joint Combat Analysis Team (JCAT) and the U.S. Army Aeromedical Research Laboratory (USAARL). In FY20, the JCAT completed 20 combat damage assessments supporting operational forces. The USAARL supported the related analysis of aircraft combat injuries and documented all reported AH-64 Apache combat injuries in Operation Iraqi Freedom and Operation Enduring Freedom. To enable combat incident data access across the DOD, Services, and CCMDs, JASP transitioned the Combat Damage Incident Reporting System from an Air Force SIPRNET server to NGIC hosting. In coordination with the Naval Air Systems Command, JASP also enabled automatic collection of time-sensitive threat incident and engagement data to support future aircraft combat incident reporting.

Cybersecurity

Cyber Assessments

SUMMARY

DOT&E-sponsored cyber assessments and cybersecurity operational tests in FY20 show that the Department of Defense (DOD) continues to evolve cyber defensive capabilities as well as the means to measure them. DOT&E's Cybersecurity Assessment Program (CAP) has been instrumental in helping warfighters develop defenses against advanced threats. However, development of effective capabilities remains slow and observations for this fiscal year confirm the conclusion from previous years: critical DOD missions remain at high risk of disruption from adversary cyber actions.

Despite coronavirus (COVID-19) pandemic restrictions, DOT&E continued OT&E oversight and CAP activities, although at a reduced pace, to provide insight on the DOD's cyber posture during FY20. The restrictions reduced the number of activities; however, there were still 36 OT&E events and 33 CAP assessment activities executed.

Some DOT&E-sponsored assessment activities continued without impact from COVID-19, most notably the Persistent Cyber Operations (PCO) activities run by the U.S. Army's Threat Systems Management Office (TSMO). TSMO teams continued assessment missions remotely for six Combatant Commands (CCMDs). They also performed several special assessments and acquisition-program testing, with emphasis on providing rapid feedback on identified vulnerabilities, and options to improve sensor configurations and network-defense procedures. The U.S. Air Force 177th Information Aggressor Squadron also provided critical support to PCO assessments during FY20. At the end of the fiscal year, the Missile Defense Agency approved expanded PCO activities for networks supporting Ballistic Missile Defense, and the Defense Information Systems Agency (DISA) approved PCO assessments for the DOD Information Network (DODIN). Plans are maturing to add PCO cells that will focus on Service networks.

DOT&E also supported special requests by U.S. Cyber Command, the DOD Chief Information Officer (CIO), and the Defense Threat Reduction Agency for rapid-response assessments of emerging capabilities and critical network components. Examples of these assessments included a prototype Zero-Trust Network, a concept that demonstrated the potential to markedly improve the security of the DOD's networks, and Nuclear Command and Control networks and systems. DOT&E also provided cyber expertise to assess the cybersecurity of essential technologies such as cloud services, aircraft safety and communications systems, and critical infrastructure.

DOT&E subject matter experts assisted with operational assessments of offensive cyber operations tools and procedures, developed specialized tools and techniques to assess non-internet protocol (IP) communication buses, and integrated cyber-centric intelligence. DOT&E initiatives such as PCO and the Advanced Cyber Operations (ACO) Team made top-notch cyber expertise available for rapid, on-demand assignment to assessment teams.

The operational pause caused by COVID-19 for other planned activities provided DOT&E the opportunity to review and improve CAP procedures and ensure the program can continue to address priority missions in an increasingly austere budget environment. These efforts will ensure CAP remains an extremely cost-effective program. CAP expenditures represent only about 3 percent of the annual DOD exercise program cost. Large exercises typically range from $8 Million to $18 Million to plan and execute, with CAP assessment activities generally costing between $400,000 to $800,000. These activities include the planning, execution, analyses, and reporting by the assessment team; support from Red Teams and in many cases from the PCO teams; and special support from a cyber threat-intelligence team. The return on this small investment is large; CAP activities ensure warfighters train as they will fight, in a realistic environment that includes cyberattacks. DOT&E assessment data show that commands that train routinely in cyber-contested environments provided by the CAP can better sustain their critical missions, with fewer losses, when under attack.

Over the life of the CAP program, assessment teams have assisted in bringing realistic cyber elements into 16 pre-deployment exercise certifications for major Army and Marine Corps forces during combat operations in Iraq and Afghanistan. They similarly supported 11 pre-deployment exercises and certifications for naval strike and amphibious groups. In the course of these and other assessments, DOT&E-sponsored assessment teams identified many vulnerabilities, and beyond the identification phase, helped remediate serious cybersecurity shortfalls in DOD systems and weapons platforms via 65 dedicated events focused on vulnerability remediation.

A unique and critical part of the CAP is a fusion cell which integrates cyber and kinetic opposing-force elements during exercises in order to demonstrate cyber impacts to the command's missions. This fusion cell enables DOT&E to highlight and help mitigate those cyber vulnerabilities that could most seriously impair critical missions. During the COVID-19-induced operational pause, DOT&E identified a number of focus areas that will continue to improve the CAP's ability to emulate advanced nation-state adversaries to help the DOD improve its ability to complete critical missions in the face of cyber threats.

The resources and expertise needed for realistic OT&E and assessments during exercises continue to increase due to the ever-increasing number and variety of cyber threats coupled

with a growing number of events, including events that involve coalition partners and agencies outside of the DOD. DOT&E's efforts to acquire an adequate supply of cyber capabilities are greatly hindered by the chronic deficit of cyber expertise available to the DOD. Emerging technologies that are enabled by artificial intelligence and machine learning will soon call for entirely new assessment tools and methods, and will intensify the expertise gap. To close this gap, the DOD urgently requires a well-funded and widely accessible pipeline of cyber expertise from sources such as academia, Federally Funded Research and Development Centers (FFRDCs), and the national labs.

CYBER ASSESSMENT ACTIVITY

In FY20, as in previous years, DOT&E supervised cybersecurity OT&E for programs on DOT&E oversight, and performed cybersecurity assessments of operational networks and systems leading up to and during CCMD and Service training exercises. DOT&E also supported cyber defender exercises, assessments of offensive cyber capabilities and targeting, and mission-effects analyses to characterize the operational implications of cyber threats.

The number of cyber events was slightly less than two-thirds that of previous years (69 in FY20 compared to 114 in FY19). Postponements and cancellations due to the response to COVID-19 notably contributed to the reduction of events in FY20. DOT&E adjusted operations to accommodate COVID-19 by, for example, using telepresence technologies to monitor and guide assessments while maintaining travel and distancing guidelines.

Operational Test and Evaluation with Cybersecurity

DOT&E continued to emphasize the importance of cybersecurity OT&E for all systems that transmit, receive, or process electronic information by direct, wireless, or removable means. DOT&E focuses cybersecurity OT&E on the evaluation of whether combat forces can complete operational missions in a cyber-contested environment. In FY20, DOT&E monitored more than 36 tests across 23 acquisition programs. This is about half of the number conducted in FY19 because COVID-19 restrictions slowed the progress of many DOD programs.

Over the last several years, the operational test agencies have increased the rigor and scope of cybersecurity OT&E for systems that rely on the IP. A significant gap remains in the development of tools and techniques needed to test specialized protocols, such as those used in industrial control systems, tactical data links, and aircraft transponders. DOT&E is working with the Services and other agencies (such as the Federal Aviation Administration) to address that gap.

Cybersecurity Assessment Program (CAP)

DOT&E's CAP worked with the CCMDs and Services to build and execute Cyber Readiness Campaigns. These campaigns provided DOT&E assessment opportunities via a series of focused events throughout the year, while affording the commands training in realistic environments to improve their cyber capabilities. In FY20, DOT&E provided resources for assessment teams, intelligence subject matter experts, and cyber Red Teams to plan and conduct the 27 cybersecurity-related assessments and support the six PCO efforts listed in Table 1. The number of assessments in FY20 is about three-quarters of the 46 in FY19. The major exercises assessed were Global Lightning 2020, Global Thunder 2020, Juniper Cobra 2020, Littoral Combat Ship (LCS)-Exercise, Pacific Sentry 20-2, USS *Dwight D Eisenhower* Carrier Strike Group, USS *Iwo Jima* Amphibious Ready Group and Marine Expeditionary Unit (ARG/MEU), Trident 2020-2, and Trident 2020-4. Assessment focus areas included:

- Mission assurance in cyber-contested environments
- Performance of network and system defenses when under attack
- Timeliness of attack detections and response actions
- Ability of physical security measures to protect facilities with network or system assets
- Planning and employment of offensive cyber capabilities
- Remediation support to facilitate fixes to identified problems

The CAP Cyber Readiness Campaigns continue to improve both technical and process-oriented measures for cyber defense; this in turn has led to increased demand for cyber expertise to support these campaigns. As CAP expands adversary portrayal and assessments to more dimensions of the cyberattack surface, the program will identify additional cybersecurity risks and risk mitigations related to the internet of things, wireless technologies, industrial control systems, cloud technologies, and artificial intelligence.

Persistent Cyber Operations (PCO)

PCO provide cyber Red Teams with longer dwell time on DOD networks to probe selected areas and to portray advanced adversaries that typically conduct long-duration, stealthy cyber reconnaissance to identify cybersecurity weaknesses without being detected. PCO also afford the opportunity to identify more important and pervasive vulnerabilities, and provide more realistic training for cyber defenders. PCO enabled DOT&E to continue assessment operations during the COVID-19 response, providing assessments to CCMDs on how to best adjust their sensors and tools to facilitate operations by off-site personnel. The ability to continue operating and dynamically respond to evolving requests contributed to FY20 having the highest demand and operational tempo yet for PCO.

In FY20, DOT&E resourced PCO at six CCMDs. PCO activities expanded at the end of the fiscal year to include networks supporting Ballistic Missile Defense and the global DODIN, and plans are maturing to add PCO cells that will focus on all major Service networks.

DOT&E works with TSMO to coordinate PCO activities and report on vulnerabilities that span functional or geographic areas of responsibility. The demand for PCO support continues to increase, highlighting the interest in cyber activity at times other than during tests and exercises. The limited availability of cyber expertise within the DOD is a factor that limits both the growth of the PCO, and its ability to emulate the most advanced cyber threats.

Advanced Cyber Operations (ACO)

DOT&E resources an ACO team to augment cyber Red Teams with specialized cyber expertise and develop new cyber tools, tactics, techniques, and procedures. During FY20, the ACO supported:

- Assessments of the Joint Regional Security Stacks
- Cybersecurity testing of the F-35
- Assessments of offensive cyber operations capabilities
- Cybersecurity assessment of the IKE planning and execution tool that supports U.S. Cyber Command (USCYBERCOM) operations
- Assessment of Office 365 Zero-Trust Network
- Assessments of industrial control systems
- Development of enhanced Red Team capabilities
- Stand-up of a new Red Team location in Maryland

Demand for ACO support grew dramatically during FY20, and requests for FY21 will likely drive further expansion of the ACO Team, subject to available cyber expertise.

Assessment of Offensive Cyber Capabilities

DOT&E continued collaboration with offensive cyber capability developers and testers, helping to integrate more operationally realistic elements into assessments of these capabilities. DOT&E observed demonstrations or performed assessments of seven offensive cyber events in FY20 and assessed processes for planning cyber fires during exercises with U.S. Indo-Pacific Command (USINDOPACOM). Examples of capabilities examined during FY20 assessments ranged in sophistication from tactical devices used to help defeat terrorists to advanced cyber/electromagnetic spectrum attacks designed for use against nation states.

Engagement with the Intelligence Community

DOT&E continued to partner with the Intelligence Community to employ and improve cyber-related intelligence. Such intelligence ensures the realism of cyber threats portrayed during OT&E and CAP assessments, and is a critical foundation for the development of adequate cyber defenses.

Collaboration with Naval Postgraduate School

DOT&E's outreach to the academic community includes working with the Naval Postgraduate School to sponsor applied research projects in cyber topics, including an Insider Threat detection capability using statistical network-traffic modeling, and tools to increase the fidelity of virtualized networks and components. These efforts have resulted in a toolkit that the Navy has employed, and which is being transitioned for joint use.

Special Project Assessments

DOT&E performed multiple special assessments in FY20 requested by USCYBERCOM, the DOD CIO, OSD's Joint Service Provider, DISA, and U.S. Southern Command (USSOUTHCOM). These assessments provided cyber expertise to assess priority missions and emerging technologies to include:

- Proposed perimeter cybersecurity defenses for the SIPRNET
- Cloud-based models for Zero-Trust network and endpoint security
- Grey space network flow analysis of DODIN components
- Nuclear command, control, and communications

Special assessment methodologies and outcomes were shared with requesting organizations and will inform the broader CCMD and Service Cyber Readiness Campaigns, as well as cybersecurity OT&E of acquisition programs.

EXAMPLES OF FY20 OBSERVATIONS AND ACCOMPLISMENTS

PCO Contributions during COVID-19

During the early days of the COVID-19 response, when travel by DOD personnel was largely stopped, DOT&E expanded PCO assessment activities. When the DOD implemented the Commercial Virtual Remote (CVR) environment as a rapidly deployed solution to enhance telework, the PCO found configuration management vulnerabilities that would enable an adversary to gain unauthorized access to unclassified CCMD networks, reported them to USCYBERCOM, and the DOD CIO issued guidance for remediation. The PCO also worked directly with CCMD network defenders to help them test and secure their networks and security baselines. The PCO's real-time feedback allowed CCMDs and supporting defenders to implement fixes and new security technologies, provided positive training, and resulted in improved cybersecurity.

Joint Regional Security Stack Assessments

DOT&E's ACO team and the DISA Red Team performed an assessment of the SIPRNET-Joint Regional Security Stack (S-JRSS). Assessment results identified multiple poor cybersecurity findings, which contributed to DISA shutting down existing S-JRSSs, and the DOD CIO to delay future S-JRSS deployments until FY23.

DOT&E also worked with DISA to conduct a comparative analysis of operational JRSS cybersecurity logs with network flow information gathered by commercial vendors. These data are helping JRSS operators recognize potential adversarial activity, tune their defensive tools, and remedy gaps in incident response processes.

Zero-Trust Architecture Assessment

DOT&E helped lead the USCYBERCOM-sponsored Microsoft Office 365 Design and Implementation cybersecurity validation events to assess how implementation of Zero-Trust principles in cloud-based environments could improve the DOD's cybersecurity posture. Initial results indicate that a Zero-Trust design, properly implemented in a DOD network, could provide significantly better cybersecurity than the DOD's current perimeter defense design.

Assessment of Tanium Endpoint Security

In FY19, DOT&E provided ACO assessment support to DISA to examine the ability of Tanium to provide endpoint protection and application control across the DOD. The ACO assessment identified multiple issues, and DOT&E continued assessment support through FY20 as the developer experimented with solutions and ultimately delivered an improved product. Tanium is helping safeguard more than two million DOD computers.

Implications of adversarial exploitation of compromised information

DOT&E conducted research with the Federal Bureau of Investigation's National Cyber Investigative Joint Task Force for several acquisition programs to explore implications of adversarial exploitation of known compromised information. The efforts provided insights into the criticality of supply chain security to cybersecurity posture and operations. DOT&E continues this research to inform planning and conduct of OT&E and training exercises.

WAY AHEAD

For the FY21 CAP, DOT&E will continue to increase the realism of our assessments to accurately test the warfighter's ability to sustain critical missions that are contested and degraded by an advanced cyber adversary. Ready access to a talented cyber workforce and advanced tools are all essential, and DOT&E will continue to advocate that the DOD establish a well-resourced pipeline of cyber talent from academia, the FFRDCs, and the national labs. Overarching CAP assessment objectives developed during FY20 include the following:

Assess Mission Assurance with Network Degradation

Exercise planners are generally reluctant to allow threat-realistic cyberattacks that degrade network operations. This limits DOT&E's ability to help improve warfighters' ability to withstand such attacks. DOT&E will prioritize funding for assessments that permit realistic degradation to networks and the missions they support. Such assessments will enable DOT&E to better assess the DOD's mission-assurance posture and will help warfighters improve their playbooks in order to sustain missions under realistic wartime conditions.

Improve Assessments and Tests of Offensive Cyberspace Operations (OCO) Capabilities and Processes

As OCO capabilities grow in importance, operationally realistic testing of these capabilities is not as routine or rigorous as is needed to provide confidence to commanders that the capabilities will work as designed. DOT&E's OCO Assessment Team will continue to plan and execute operational assessments with Service representatives and the Cyber Mission Force to help improve confidence in OCO capabilities and processes, and inform future operational testing. DOT&E will work to overcome the following challenges to enable adequate assessments and OT&E on OCO capabilities:

- Testers need better access to advanced cyber expertise to plan and execute tests on advanced OCO technologies.
- Testers need improved access to intelligence on threat targets and defensive capabilities surrounding these targets.
- Red Teams need training and capabilities to portray near-peer adversaries for targets of interest.
- Test ranges are needed to assess the effectiveness of cyber capabilities delivered by over-the-air transmissions.

Special Assessments for Cross-Cutting Technology

DOT&E will continue to grow capabilities to assess emerging technologies and other critical warfighting technologies for which threat-realistic cyber assessments are lacking. These will include efforts to explore and stress the security of cloud computing; assess cybersecurity of aircraft transponders; examine the convergence of cyber and electromagnetic spectrum operations; assess specialized communications protocols; and assess cybersecurity of critical infrastructure supporting DOD installations, organizations, and systems.

During FY20, DOT&E established an Industrial Control System Working Group (ICS WG) to assess vulnerabilities and improve cyber defense at the facility-related ICS level and develop a methodology for integrating ICS assessments into CAP. The first assessment is a scheduled ICS Pilot at USSOUTHCOM in early December 2020. The pilot will assess the risks, threats, and vulnerabilities at the convergence point between the ICS/Supervisory Control and Data Acquisition and the Information Technology/IP systems. The data will be mapped to the MITRE ICS ATT&CK framework of attack techniques, and integrated with Sandia National Lab's SCEPTRE to emulate, test, and validate control system security.

Implement Remote Assessment Technologies

The response to the COVID-19 pandemic impacted the planning and execution of many assessments scheduled for FY20 and created the need for options to conduct assessments and tests with reduced on-site presence. DOT&E will continue experimentation with the Test Resource Management Center on available and emerging remote/telepresence capabilities for an array of use cases that represent typical assessment and test venues. The objective is to find a workable balance of virtual and in-person activity to meet the requirements of both OT&E oversight and CAP core missions across the array of classified events and environments where data bandwidth is a challenge.

TABLE 1. CYBERSECURITY OPERATIONAL TESTS AND ASSESSMENTS IN FY20		
EVENT TYPE	**ACQUISITION PROGRAM OR TYPE OF EVENT**	
Programs Completing Operational Tests of Cybersecurity	Aerosol and Vapor Chemical Agent Detector	Global Command and Control System - Joint
	Air Operations Center - Weapon System	Global Positioning System Contingency Operations
	Amphibious Combat Vehicle Family of Vehicles	Interim Mobile Short Range Air Defense
	AN/SQQ-89A(V) Integrated Undersea Warfare Combat Systems Suite	KC-46 - Tanker Replacement Program
	Army Integrated Air & Missile Defense	Limited Interim Missile Warning System
	Bradley	Maneuver-Short Range Air Defense
	Defense Enterprise Accounting and Management System	Military Global Positioning System User Equipment
	Deliberate and Crisis Action Planning and Execution Segments	RQ-7B SHADOW - Tactical Unmanned Aircraft System
	DOD Healthcare Management System Modernization	Space-Based Infrared System Program
	Electronic Warfare Planning and Management Tool	Stryker Anti-tank Guided Missile
	F-35 - Lightning II Joint Strike Fighter Program	Wide Area Surveillance
	Family of Beyond Line-of-Sight Terminals	
Cybersecurity Assessment Program	**Physical Security Assessment (1 Event)** USSOCOM	
	Cooperative Network Vulnerability Assessment (3 Events) USAFRICOM, USINDOPACOM, USFK	
	Assessments of Network Security, Stimulation Exercises, and Phishing Campaigns (5 Events) USAFRICOM, USNORTHCOM, USSOUTHCOM, USFK (2)	
	Assessment of Mission Effects during Exercises (11 Events) USCENTCOM, USNORTHCOM, USSTRATCOM (2), USSOCOM (2), USEUCOM, USINDOPACOM, U.S. Navy (3)	
	TAssessment of Cyber Fires Processes for Offensive Cyber Operations (1 Event) USINDOPACOM	
	Assessments of Offensive Cyber Operations Capabilities (6 Events) USCYBERCOM (3), USINDOPACOM (2), USSOCOM	
	Assessments During Persistent Cyber Operations (6 Efforts) USCENTCOM, USEUCOM, USINDOPACOM, USNORTHCOM, USSTRATCOM, U.S. Air Force	
USAFRICOM – U.S. Africa Command; USCENTCOM – U.S. Central Command; USCYBERCOM – U.S. Cyber Command; USEUCOM – U.S. European Command; USFK – U.S. Forces Korea; USINDOPACOM – U.S. Indo-Pacific Command; USNORTHCOM – U.S. Northern Command; USSOCOM – U.S. Special Operations Command; USSOUTHCOM – U.S. Southern Command; USSTRATCOM – U.S. Strategic Command		

Test and Evaluation Resources

Test and Evaluation Resources

Test and Evaluation Resources

By title 10 USC, DOT&E is to assess the adequacy of test and evaluation (T&E) resources and facilities for operational and live fire testing and evaluation. DOT&E monitors and reviews DOD- and Service-level strategic plans, investment programs, and resource management decisions that affect realistic operational and live fire tests. This section discusses areas of concern in T&E infrastructure needed for adequate operational and live fire testing of current and future systems, the associated challenges, and makes recommendations. Specific areas include:

- Modernizing T&E Infrastructure for National Defense Strategy (NDS) Technologies
- T&E Workforce for the NDS
- Chemical, Biological, Radiological, and Nuclear Survivability Test and Evaluation Capability
- Open-Air Range Modernization
- Threat Representation for OT&E of Space Systems
- Missile Defense – Pacific Collector and Pacific Tracker Ship Replacement
- Advanced Satellite Navigation Receiver (ASNR)
- Fifth-Generation Aerial Target (5GAT)
- Navy Aerial Targets and Payloads
- Navy Surface Warfare (SUW) Targets
- Naval Test Infrastructure Upgrades
- Submarine Target and Countermeasure Surrogates for Torpedo Testing
- Army Manning and Test Technologies for OT&E
- Electronic Warfare (EW) and Navigation Warfare (NAVWAR) for Land Combat
- Tactical Engagement Simulation with Real Time Casualty Assessment (TES/RTCA)
- Threat Modeling and Simulation (M&S) for T&E
- Foreign Materiel Acquisition Support for T&E
- Allied Nations Partnerships for T&E
- Earthquake Damage to T&E Infrastructure
- 5G and Radio Frequency (RF) Spectrum for T&E
- Range Capabilities and Sustainment

Modernizing T&E Infrastructure for NDS Technologies

The 2019 DOD Appropriations Act authorized $150 Million to DOT&E for modernizing DOD T&E infrastructure in areas such as hypersonics, directed energy, artificial intelligence, machine learning, robotics, and cyberspace. In FY19, DOT&E partnered with the Test Resources Management Center (TRMC) in the Office of the Under Secretary of Defense for Research and Engineering [OUSD(R&E)] and the Services to align T&E infrastructure investments with advanced technology roadmaps. DOT&E and the TRMC developed an investment strategy and managed T&E infrastructure modernization program implementation. In FY20, this investment supported T&E infrastructure capabilities in the following NDS advanced technology areas and will be transitioned to test ranges, the Services, and TRMC for sustainment as they are completed:

- Hypersonics ($55 Million). Telemetry and optics instrumentation for unmanned aerial, atmospheric measurement capabilities, and capability supporting end-game scoring and weapons effects.
- Directed Energy ($57 Million). High-Energy Laser (HEL) instrumentation and atmospheric characterization, HEL target and scoring boards, high-power microwave (HPM) diagnostics.
- Big Data Analytics ($28 Million). Analytics to evaluate next generation aircraft.
- Autonomy / Cyberspace ($10 Million). Autonomous cyber threat emulation (“Red Team”) tools.

TRMC proposed a $10 Million investment in artificial intelligence (AI)/machine learning test tools to stress AI data-fusion algorithms in FY19. Based on limited options for developing effective test tools, this funding was reallocated to directed energy and big data analytics projects in FY20.

T&E Workforce for the NDS

The NDS and USD(R&E) modernization priorities focus on development of capabilities based on advanced technology areas such as hypersonics, directed energy, autonomy, artificial intelligence, and technological innovations to computation, communications, navigation, and sensor capabilities based on quantum physics. Development and testing of systems using these technologies requires an adequately trained and qualified workforce in adequate numbers to develop and implement test strategies and provide the infrastructure to characterize their performance. For example, autonomous systems that rely on AI and machine learning are being developed to provide new capabilities that span warfighting functions from intelligence analysis and mission sustainment to force protection and medical treatment of casualties. Autonomous systems are expected to team with human users and/or other autonomous systems, may learn and evolve over time, and potentially exhibit emergent behavior. Understanding the operational performance of autonomous capabilities will require a knowledgeable and multi-disciplinary T&E workforce. Testing autonomous systems requires development of testing methods, evaluation frameworks, and architectures, to include development of autonomy countermeasures, test beds, M&S capabilities, and test ranges to observe and analyze performance. The following are recommended to improve access to the highly skilled and talented human capital needed to test and evaluate advanced technology weapon systems:

- Incentivize development of the civilian T&E workforce through establishment of a T&E career path that includes education and training opportunities and rotational assignments.
- Provide professional pay for hiring civilians with special knowledge and skills in high demand.
- Establish/expand scholarships, internships, and fellowship programs to attract new talent to the defense T&E community.
- Expand use of expertise at Federally Funded Research and Development Centers, National Laboratories, University-Affiliated Research Centers (UARCs), and universities.
- Establish federated UARCs in specific technology areas to enable DOD access to world-class expertise.

Chemical, Biological, Radiological, and Nuclear Survivability Test and Evaluation Capability

The Chemical, Biological, Radiological, and Nuclear (CBRN) Survivability Oversight Group, established by the CBRN Survivability Policy, has identified several T&E infrastructure shortfalls that should be addressed to enable adequate assessment of the U.S. nuclear deterrent posture. To enable adequate testing and evaluation of several ongoing nuclear modernization programs, the DOD should:

- Continue to improve T&E infrastructure and M&S tools to adequately evaluate the effects of nuclear blast-generated cold and warm X-ray environments on DOD systems. This is a critical T&E shortfall for the Ground Based Strategic Deterrent (GBSD) program, and the CBRN Survivability Oversight Group – Nuclear estimates funding requirements of $51 Million in the near-term (1-2 years) and $79 Million for the life of the program to establish this T&E capability.
- Continue establishment of an in-house capability to evaluate nuclear blast-generated pulsed neutron environment effects. The DOD is currently relying on Department of Energy facilities that are not readily available and can only handle small, coupon-sized items. This shortfall limits our ability to evaluate GBSD survivability in appropriate fusion flux. The CBRN Survivability Oversight Group – Nuclear estimates that $28 Million is needed for this capability.
- Upgrade existing test facilities and wind tunnels to evaluate the durability of our systems in lofted radioactive dust and debris after a nuclear blast. The combined abrasive and chemical effects of such an environment can cause damage to optical sensor windows, leading surface edges, hot engine components, and other key systems and sub-systems. CBRN Survivability Oversight Group – Nuclear estimates $8 Million for the cost of this capability.
- Continue to improve T&E infrastructure to enable the assessment of combined effects in a nuclear environment. The combined nuclear effects can disrupt electronic, propulsion, sensor, and other systems, as well as degrade weapon's flight and other surfaces in ways that are difficult to predict. For example, combined effects of neutron exposure and electromagnetic pulse could potentially affect GBSD systems, and these combined effects would only be identified by testing systems in an environment with combined phenomena.

CBRN T&E infrastructure must be adequately resourced and maintained to handle multiple types of current and emerging CBRN threats and to test the CBRN capabilities that enable our ability to operate in hostile CBRN environments.

Open-Air Range Modernization

Existing laboratories and range systems do not reflect current or future threat laydowns, and must be upgraded for both flight test and training missions. Improvements include but are not limited to the following:

- Connecting U.S. test and training ranges via secure networks.
- Acquisition of additional high fidelity, rapidly reprogrammable, open-air threat emulation systems.
- Upgrades to current high fidelity systems in order to provide greater flexibility to the ranges in support of the warfighter.

Full funding is required to provide the necessary test and training capabilities that enable real-time battle-shaping of open-air missions. Collection of critical, open-air mission data is also necessary for verification, validation, and accreditation of associated M&S capabilities.

Threat Representation for OT&E of Space Systems

U.S. warfighting capabilities rely heavily on space-based systems for situational awareness, communications, and precision targeting. In recent years, Russia, China and other potential adversaries have worked to diminish U.S. warfighting advantages by developing capabilities designed to degrade our space systems. The DOD currently lacks the T&E infrastructure to adequately represent many space threats, including attacks using cyber, electronic warfare, kinetic weapons, nuclear detonations, and directed energy. While some limited threat-representative capabilities do exist, they are not widely known nor utilized within the DOD T&E community.

In 2019 and 2020, the U.S. Air Force began an initial buildup of space systems T&E infrastructure to address known T&E capability gaps, primarily focusing on foundational infrastructure elements that are cross-cutting, enduring, and usable across multiple space systems. Despite these initial investments, the current and planned level of resources is insufficient to enable adequate threat testing of the many space programs currently under development. DOT&E estimates $100 Million per year across the Future Year Defense Program (FYDP) is required to adequately test existing space programs against validated threats, and that investment will need to continue beyond the FYDP to address emerging threats. To help address this resource mismatch, TRMC in conjunction with DOT&E and the Services, is developing a space test capabilities investment roadmap to document all significant gaps to ensure the development of a National Space Test and Training Range capable of representing realistic threats to space systems.

Missile Defense – Pacific Collector and Pacific Tracker Ship Replacement

Missile defense testing is conducted over the broad ocean area due to the expansive area required for safe missile flight. The Missile Defense Agency requires extensive instrumentation to conduct flight test operations, which to date has been provided by two highly instrumented ships:

- The Pacific Collector is the host to the Transportable Telemetry System-1 (TTS-1) and serves to collect full-trajectory telemetry truth data beyond existing test ranges and land-based instrumentations sites. Further, it integrates a range safety system with the TTS-1 and Satellite Communications to maintain positive control over a missile flight termination system during powered flight.
- The Pacific Tracker is host to the TTS-2 and the dual S/X-band Transportable Radar. It provides midcourse telemetry and the capability to characterize target complex phenomena from deployment to intercept well beyond the limitations of traditional test ranges and other land-based instrumentation.

Both ships are homeported in Portland, Oregon, and the vessels are owned, operated, and maintained by the U.S. Department of Transportation's Maritime Administration in support of Missile Defense Agency testing. They were both constructed in 1966 and are rapidly approaching their end of service life. The optimal schedule for ship and instrumentation replacement would be FY28 for Pacific Collector and FY32 for Pacific Tracker. Replacement funding needs to be programmed not later than FY23 to achieve this schedule.

Advanced Satellite Navigation Receiver (ASNR)

The DOT&E Test and Evaluation Threat Resource Activity (TETRA) project for the ASNR is intended to improve the accuracy of the Time Space Position Information (TSPI) instrumentation used to collect threat missile dynamics and performance data during flight tests. Accurate TSPI information is needed to support threat model design, and the development/improvement of U.S. countermeasure capabilities. Current TSPI instrumentation cannot capture all required data for system assessment, flight data analyses, intelligence model design, and will start becoming obsolete within the next 2 years. The ASNR task needs continued funding for completion in order to provide the Intelligence Community (IC) and test community with the required TSPI accuracy, and to mitigate obsolescence of a critical capability.

Fifth-Generation Aerial Target (5GAT)

The 5GAT team completed the fully government-owned design, delivered the first demonstration prototype aircraft, and successfully completed Air Force-led low-speed and high-speed taxi testing at Dugway Proving Grounds, Utah, in September 2020. On October 23, 2020, the first prototype experienced an in-flight mishap that resulted in the loss of the aircraft. A safety investigation is underway to determine the cause of the mishap. The prototyping effort will provide cost-informed alternative design and manufacturing approaches for future air vehicle acquisition programs. The program will also provide verified cost data for all-composite aircraft design/development and alternative tooling approaches. Early production work for the second prototype aircraft is currently underway. The DOD has requested $32.7 Million in FY21 to continue development and testing of the second 5GAT prototype aircraft. DOT&E recommends full funding for the continuation of this prototyping effort to meet the urgent need for a full-scale fifth generation aerial target that can adequately represent current and future threat aircraft characteristics. TRMC will begin managing the 5GAT program in FY21.

Navy Aerial Targets and Payloads

Improved aerial target capabilities are needed to emulate the threats for testing current and upcoming surface Navy combat systems, defensive missiles, and radars, including those of CVN 78 and DDG 51 Flight III ships.

- The BQM-74 and BQM-177 subsonic aerial target radar seeker payloads are not able to emulate some important features of anti-ship missile radars. The Navy plans an initial operational capability for a new BQM-177 emitter in 2QFY21. The BQM-74 is no longer in production and will sunset in early FY22.
- The GQM-163 supersonic aerial target does not have a payload to emulate the radar systems of modern supersonic anti-ship missiles. The Navy is developing such a program through TRMC but the current program does not provide for such a capability on high-diving GQM-163s. The Navy should continue with the current program and develop a follow-on program to provide for the diving capability.
- The GQM-163 needs kinematic improvements to allow for higher G maneuvers in the sea-skimming flight profile, and for steeper dives in the high-diver profile, such that they support testing of shipboard defensive capabilities against modern anti-ship cruise missile (ASCM) threats. If the GQM-163 cannot be sufficiently modified, the Navy will need to initiate a new supersonic aerial target program.
- Aerial targets need a responsive cruise missile seeker emulator to test integrated hard kill and soft kill air defense systems on Navy ships. Current and future operational testing of shipboard active electronic attack or decoy ("soft kill") systems, such as Surface Electronic Warfare Improvement

Program (SEWIP) Block 3, Nulka, and Advanced Off-Board Electronic Warfare, are unable to assess the effectiveness of these systems. The threat surrogates currently employed cannot emulate the threat missiles' responses, including their autopilot logic, kinematic responses, and electronic protection capabilities. They also do not fly at threat-representative speeds, altitudes, or maneuvers. The development of a programmable responsive cruise missile surrogate (RCMS) would allow for adequate effectiveness assessments of these systems, as well as the combat systems that employ them. Such an aerial target would also allow for the assessment of the host combat system's abilities to coordinate soft-kill and hard-kill (missile) systems. An RCMS would be utilized for all current and upcoming surface Navy combat system test programs that utilize soft-kill systems.

- The Navy should augment current and planned aerial target emitter systems with improved data collection regarding the details of the transmitted radio frequency emissions. These data will improve the Navy's ability to determine if ship combat systems are receiving and processing threat radar seeker information correctly.
- The increased tempo of Navy testing have exceeded the throughput capability of the GQM-163 target preparation and storage facilities. The Navy funded MILCON P-586 in FY19 which will provide an 8 bay Missile Assembly Building in FY22.
- In order to test new Navy radars, modern electronic attack test assets must be procured in sufficient quantities to support multiple concurrent ship IOT&Es. The more advanced jamming assets also need to be integrated with unmanned aerial vehicles (UAVs).
- The lack of a threat-representative multi-stage supersonic target limits the ability to assess the combat effectiveness of ship self-defense capabilities.
- A hypersonic threat missile surrogate is needed to assess combat system, radar, and missile self-defense performance against hypersonic threats and to validate M&S.

Navy Surface Warfare (SUW) Targets

The Navy actively manages surface targets, such as the high-speed maneuverable surface target (HSMST), which are used by both test and training communities. Several factors determine the availability of surface targets during the fiscal year, such as appropriated funding for new targets, the existing target inventory, the attrition rate of the targets used for test and training, and the availability of facilities for outfitting of the targets with instrumentation for operation on ranges. Adequate numbers of SUW targets are required to support T&E. For example, the Littoral Combat Ship Independence variant with SUW Mission Package Increment 3 was unable to perform operational testing in accordance with the approved test plan due to unavailablility of needed HSMST targets. The Navy requires full funding for SUW targets, such as the HSMST, to ensure that sufficient quantities are available to support test and training missions.

At present, there is limited availability of SUW targets that can exceed 45 knots. The HSMSTs can only reach speeds of about 40 knots in very flat sea states. Without adequate numbers of high-speed SUW targets, the Navy will be unable to characterize the capabilities of the weapon systems designated for defending against small boat swarms that a likely adversary might employ. Options to address this shortfall include procurement of commercial fast boats or potential use of fast boats confiscated by counterdrug authorities. An example of a commercial small boat that could serve as an SUW target is the British-produced Bladerunner, which comes in a variety of models. A Model 51 Bladerunner can reach speeds of 63 knots and costs approximately $100,000. The Navy should explore options for acquisition of high-speed SUW targets and procurement of adequate quantities of these targets for testing ship self-defense capabilities against these threats.

Naval Test Infrastructure Upgrades

Self -Defense Test Ship for Testing Shipboard Air Defense Systems

Safety constraints preclude realistic operational testing of short-range air defense systems against ASCM threats on manned ships. In order to satisfy the statutory requirement to demonstrate end-to-end performance capabilities during OT&E, this testing requires an unmanned, sea-going test platform such as the existing Self-Defense Test Ship (SDTS). In addition to providing a realistic, low-risk venue to conduct end-to-end live testing, testing on the SDTS generates critical validation data for M&S capabilities used for supplemental analysis. To ensure a capability is available to support upcoming ship class and combat systems testing, the Navy must fully fund the needed repairs to the existing SDTS for continued use, or begin procuring a replacement unmanned test asset that will support LHA 8, LPD 17 Flight II, CVN 79, and FFG 62 testing, which also encompasses operational testing of the new Enterprise Air Surveillance Radar. Urgent action is needed to address this potential shortfall given the time necessary to repair or replace the SDTS and current Navy plans to use the SDTS to support testing LHA 8 in FY24. The Navy's strategy for assessing the self-defense capability of DDG 51 Flight III relies critically on testing ESSM Block 2 on the existing SDTS. If an SDTS is not available to support this testing, the DDG 51 Flight III test strategy is no longer executable as planned.

Missile and Navy Test Range Telemetry Systems and Infrastructure

Testing of shipboard air defense systems requires that air-defense missiles be equipped with in-flight telemeters that provide missile performance data to testers. These in-flight telemeters need to be designed such that the Navy can collect data in operational tests where a representative number of missiles are fired. DOT&E recommends the following to realize this capability:

- Convert the telemeters for the Standard Missile family of missiles (e.g., SM-6 Block IA) and Evolved Sea Sparrow

Missile Block 2 from S-band to C-band for improved spatial resolution such that missile telemetry may be collected from all missiles in flight during operational tests. Without such conversion it is not possible to determine why missiles succeed or fail in operational tests involving threat representative sized raids of aerial target. The Navy programmed resources in FY22 for this conversion.
- The Navy Pacific Missile Range Facility (PMRF) and the Point Mugu Sea Range (PMSR) need telemetry upgrades to support simultaneous tracking of multiple missiles that are employed during air defense mission testing. These upgrades include installation of Active Electronically Scanned Array telemetry collection antennas and improvements to range facility equipment to support telemetry data processing. The Navy programmed resources in FY22 for these telemetry upgrades.
- A Rolling Airframe Missile (RAM) Block 2 missile telemeter that is compatible with the missile's warhead requires development. The current RAM Block 2 telemeter is incompatible with the warhead forcing operational testers to choose between having missile telemetry or having a warhead. This situation leads to uncertainty in the results of operational tests. The RAM Program Office supports this development, but the Navy has yet to fund it.

Resources Needed to Test Surface Ship Electronic Warfare Systems

The Navy traditionally tested passive electronic surveillance systems using the Shipboard Electronic Systems Evaluation Facility (SESEF), where a pulse generator, known as the Combat Electromagnetic Environment Simulator (CEESIM), an amplifier, and an antenna are used to emulate hostile radars, but such systems will not be adequate for testing active electronic warfare systems. Viable surrogates for threat airborne and surface (e.g., coastal defense) radars are needed to test and evaluate the systems required to thwart these threats. In October 2016, DOT&E identified the needs to develop such threat radar surrogates, but these surrogates are still unavailable. Without such test assets, it is unclear how the Navy will credibly test active electronic attack systems like Surface Electronic Warfare Improvement Program (SEWIP) Block 3.

Submarine Target and Countermeasure Surrogates for Torpedo Testing

The effectiveness of U.S. anti-submarine aircraft, surface combatant ships, and submarines must be evaluated against threat representative surrogates. U.S. nuclear-powered submarines and foreign diesel electric submarines are surrogates for most threats. However, the unavailability of both types of submarine targets for testing has significantly delayed or limited testing of the P-8A's Multi-static Active Coherent (MAC) anti-submarine warfare (ASW) system and upgrades to the U.S. submarine fleet's Acoustic Rapid Commercial-off-the-shelf Insertion (A-RCI) sonar system. Torpedo testing also requires a mobile, set-to-hit submarine target. The Navy completed an evaluation of set-to-hit target options in 2018 and determined the most cost effective and timely solution for a set-to-hit torpedo target is a certified U.S. attack submarine slated for inactivation. The Navy is completing an analysis to determine set-to-hit certification criteria for potential submarine targets. The Navy plans to use a combination of existing surrogates, modified artificial targets, and manned submarines to support torpedo testing. DOT&E remains concerned about capabilitiy shortfalls for ASW testing given the lack of dedicated threat representative surrogates and the Navy's submarine force structure which is not adequate to support both operational and testing demands.

In FY09, DOT&E funded the development of the Submarine Launched Countermeasure Emulator (SLACE) to provide representation of threat countermeasures that have significantly different performance characteristics than U.S. countermeasures. Further enhancement of SLACE is required to provide characteristics of modern torpedo countermeasures. DOT&E supported the use of FY19 funding to include the development of a towed array and its integration into SLACE. This will enable SLACE to emulate modern torpedo countermeasures and better inform the capabilities of lightweight and heavyweight ASW torpedoes.

Army Manning and Test Technologies for OT&E

In FY18, the Army initiated modernization and acquisition reforms through the establishment of eight Cross Functional Teams (CFTs) and the activation of the Army Futures Command (AFC). A primary goal of the AFC and CFTs is to support the rapid acquisition and fielding of new warfighting capabilities to counter advancements made by near-peer adversaries. The Army Test and Evaluation Command (ATEC) is an essential partner in the Army's modernization efforts. Within ATEC, Operational Test Command (OTC) performs a critical role by ensuring these new warfighting systems are tested as they are intended to be integrated into combat formations and thus exercise their operational dependencies (e.g. consumables, command and control, field level maintenance and repair, etc.). The Army's desire to incorporate more soldier feedback early in the development cycle, along with compressed fielding timelines, is expected to created a surge of OTC-supported testing in the FY21-FY24 timeframe. Increased weapon system complexity and rapid test-fix-test cycles requires a T&E workforce that is resourced to keep pace with the CFTs and support shorter decision timelines. Investments in cutting edge weapons technology necessitates a proportional investment in operational test technology. To meet these demands, ATEC has placed T&E professionals within the CFTs, where they willhelp synchronize data collection efforts across the testing continuum and identify test capability and resource issues early. ATEC is leveraging Army and DOD training initiatives to support the continued education of its workforce.

Beginning in FY14, DOT&E expressed concern about reductions in funding for personnel and test technology at OTC. When adjusted for inflation, there has been a 15 percent decrease in funding for OTC personnel and a 34 percent reduction in funding for OT Test Technology from FY14-FY20. Funding for operational test technology and infrastructure has not been adequate to sustain legacy data collection instrumentation, command and control networks, and live/virtual/constructive simulation capabilities. Beginning in FY21, these downward trends appear to be flattening, but DOT&E remains concerned that current funding levels will not be sufficient to support the Army's aggressive modernization goals through the FY22 Program Objective Memorandum. DOT&E acknowledges that the Army has made substantial investments in developmental test range infrastructure and test technology in support of modernization efforts, and is now planning to shift focus to OT readiness and near peer threat representation in support of Multi-Domain Operations. DOT&E recommends that ATEC continue working with the CFTs to evaluate the operational test technology needs associated with the Army's modernization priorities and increase funding to match the needs.

Electronic Warfare (EW) and Navigation Warfare (NAVWAR) for Land Combat

Over the past few decades, the Army's dedicated EW capabilities have atrophied while its vulnerabilities have grown due to the expanded dependency on terrestrial and space based networks, and the Global Positioning System (GPS). The Army must fight as a joint force and across all mission domains, the electromagnetic spectrum, and the information environment. With the establishment of the Army's Assured-Positioning, Navigation, and Timing (A-PNT) and Network CFTs, AFC is developing technologies and fielding systems that will counter EW and NAVWAR threats.

Due to the Department-wide focus on operating in contested environments, there is a high demand for intentional GPS interference environments that is stressing the DOD's current capacity to support multiple simultaneous NAVWAR test and training events. To help meet the demand, the Army should accelerate its efforts to get the Threat Systems Management Office certified to conduct advanced threat NAVWAR. Many of the Army's data instrumentation systems are dependent on commercial GPS receivers for PNT information and cannot function properly in a GPS contested environment. The Army should immediately begin to incorporate alternative PNT technologies into its intrumentations systems in order to support this testing.

Providing a realistic threat environment during OT is essential to ensuring that systems are survivable and will support units operating in the contested environments described in the MDO concept and the National Defense Strategy. Threat EW and NAVWAR environments should be considered for all OT, and are critical to the operational testing of future Army network initiatives, Nett Warrior/Leader Radio, Manpack Radio, Mission Command Systems, Electronic Warfare Planning and Management Tool, and A-PNT.

Tactical Engagement Simulation with Real Time Casualty Assessment (TES/RTCA)

Realistic operational environments and a well-equipped opposing forces (OPFOR) intent on winning are fundamental to the adequate operational test of land and expeditionary warfare combat systems. Force-on-force battles between live tactical units is a preferred method of creating a complex and evolving battlefield environment for test and training. Tactical Engagement Simulation with Real Time Casualty Assessment (TES/RTCA) systems integrate live, virtual, and constructive components to enable these force-on-force battles and provide a means for simulated kinetic and non-kinetic engagements to have realistic outcomes. TES/RTCA systems also record the time-space position information, and firing, damage, and casualty data for all players and vehicles in the test event as an integrated part of the test control and data collection architecture.

Current TES/RTCA systems have not kept pace with modern threat capabilities and the threat conditions found in full-spectrum warfare. Many of the new combat systems being developed under the Army's modernization priorities (Long Range Precision Fires, Next Generation Combat Vehicles, Future Vertical Lift, Army Network, Air and Missile Defense Capabilities, and Soldier Lethality) will have advanced technologies that will need to be replicated in a TES system. Without upgrades to TES/RTCA systems, force-on-force testing will not be representative of the full-spectrum warfare as detailed in the Army's MDO 2028 concept and the NDS.

Beginning in FY20, the Army cut funding for the Integrated Live, Virtual, Constructive, Test, and Training Environment (ILTE) program that was to acquire the TES/RTCA upgrades. Cutting funding to ILTE is counter to the NDS to "build a more lethal Force" and the Army modernization and readiness priorities. The Army has indicated that it will be restarting ILTE funding beginning in FY22 and better synchronizing requirements across Army stakeholders. DOT&E and the TRMC are supporting ILTE upgrades in FY21 by providing Resource Enhancement Program funds. Sustained investment and upgrades in TES/RTCA capabilities are necessary for testing systems such as Next Gen Squad Weapon, Amphibious Combat Vehicle, Bradley and Abrams Upgrades, Armored Multi-Purpose Vehicle, AH-64E Block III, Mobile Protected Firepower, Stryker Upgrades, and Next Generation Combat Vehicle.

Threat Modeling and Simulation (M&S) for T&E

The DOT&E TETRA team leads the Threat M&S Working Group Enterprise in the development of common, Intelligence Community (IC)-endorsed threat models used in T&E. M&S will play an increasing role in T&E efforts, and the U.S. is at risk of a degrading technological advantage without accurate, authoritative M&S capabilities. TETRA promotes threat M&S development based on an enterprise management process that provides interoperability standards to facilitate data correlation with threat models across the T&E enterprise. Funding has been allocated to develop, validate, and deliver at least 10 RF and 10 infrared high-priority threat models. These threat models encompass a combination of digital models, software-in-the-loop models, high-fidelity hardware-in-the-loop models, flyout models, missile signature models, and high-fidelity missile seeker models. Additional funding will be required to fully develop required near-peer threat models for future battlefield environments. DOT&E recommends continued funding for development of required threat models in collaboration with the IC for systems T&E.

Foreign Materiel Acquisition Support for T&E

Actual foreign materiel and the information gained through the exploitation of foreign materiel is critical to developing and fielding weapons that work. DOT&E and TETRA develop an annual prioritized list of foreign materiel requirements that are submitted to the Joint Foreign Materiel Program Office (JFMPO) to inform whole of government materiel collection priorities. There is a need to identify and develop new sources and opportunities for acquiring foreign materiel. Foreign materiel acquisitions are often lengthy and unpredictable, making it difficult to identify appropriate year funding. DOT&E continues to recommend a no-year or non-expiring funding line for foreign materiel acquisitions, funded at a level of $10 Million per year for Office of the Under Secretary of Defense for Intelligence & Security.

Allied Nation Partnerships for T&E

The DOT&E TETRA Team supports ongoing allied nation partnerships to improve federated T&E capabilities. TETRA represents DOT&E as the Executive Secretary for the NATO Sub-Group 2 Planning Committee and fills several critical leadership positions on the Multinational Test & Evaluation Program (MTEP) and the Air Electronic Warfare Cooperative Test & Evaluation Project Arrangement (Air EW CTE PA). TETRA promotes the development and execution of a multi-year roadmap to improve the M&S tools, capabilities, and architecture for synthetic and live T&E efforts supporting national and collective requirements. DOT&E recommends continued support of the T&E partnerships with allied nations.

Earthquake Damage to T&E Infrastructure

Naval Air Weapons Station, China Lake, California endured magnitude 6.4 and 7.1 earthquakes in July 2019. The China Lake Ranges provide 25 percent of all DOD range capability for the mission areas that they support. Recovery efforts now underway are enabled by a $3 Billion Congressional appropriation for recovery. This funding supports 18 MILCON projects and associated instrumentation and measurement capabilities at South Airfield, Propulsion Laboratory, Main Base, Main Magazine Area and the Range Control Complex. Nine projects have been awarded in 2020 with construction starting in 2021, and the remaining nine projects are expected to award in 2021. VX-31 is back to 70 percent capacity with full capability forecast for the 1QFY24. Range operations have been restored to 75 percent capacity with full capacity expected by summer 2021, when classified temporary test bays are operational. Heavily damaged ordnance T&E facilities associated with insensitive munitions, environmental qualification, and warhead testing were restored to limited capacity, with a return to full capacity on track for completion in 2021. Large and small motor testing and X-ray capabilities are dependent on the award of three MILCON projects scheduled for award in 2021. The key acquisition programs affected include F/A-18 family of systems, Air Force Unmanned Aerial System (UAS) programs, F-35, Trident, Tomahawk, AIM-9X, AV-8B, Army Deliberate Attack, and T&E support to Australian and UK armed forces.

5G and Radio Frequency (RF) Spectrum for T&E

National spectrum policy supports turning over more spectrum resources to commercial users in frequency bands currently used to support our testing and training. This spectrum sell-off is occurring at the same time the Department is expanding network centric systems, increasing our spectrum needs.

The RF spectrum required for 5G includes radio frequencies below 6 gigahertz (GHz), and at or above 24.25 GHz (millimeter-wave frequency). The entire 3.1–3.55 GHz band, also referred to as middle or "mid-band", is allocated to both federal and non-federal radiolocation services, with federal services currently receiving priority. RF spectrum in this part of the 5G range is a crucial part of DOD's test and evaluation infrastructure. It enables detectability measurements (e.g., radar cross-section) of warfighting systems; realistic threat representation, such as replicating emissions of adversary systems; electronic warfare system assessments (jammer effectiveness and vulnerability to electromagnetic effects); detection and targeting-radar testing necessary to evaluate hostile-fire identification, counter-UAS, and counter-fire systems; and communications systems testing across multiple geographic locations. The 3 GHz mid-band is also critical to operation of air, land, and sea combat radars.

The Federal Communications Commission (FCC) has formally initiated commercialization of a broad portion of mid-band spectrum where, until now, federal users were given precedence. This policy change, which will auction the 3.45–3.55 GHz range, could significantly affect military radar operations and the aforementioned vital test capabilities, jeopardizing testing and delaying development of some of the Department's most critical systems. The DOD is forming a transition plan to share this mid-band section with the private sector as co-primary users, yet it remains a requirement for realistic operational test and evaluation and warfighter training. It is imperative that future spectrum sales be carefully structured to ensure no additional loss of capabilities and that adequate spectrum is available to satisfy current and future DOD testing requirements.

Range Capabilities and Sustainment

DOT&E continues to monitor activities with the potential to limit the ability of the Department to fully use test and evaluation infrastructure. The following continue to be areas of particular concern:

Mission Space

Operational testing of hypersonic weapons, directed-energy systems, and autonomous and unmanned vehicles is either now underway or planned in the near future. Adequate operational testing will require long-range corridors that are in excess of currently available air, land, and sea space. The Department is concerned about certain areas of the mid-Atlantic and off the coast of California, which are being considered for wind power development. Our previous concern regarding the eastern Gulf of Mexico statutory moratorium on oil and gas development, which was scheduled to expire in 2022, has been alleviated by the administration recently extending this moratorium through 2032. Federal land withdrawals for the Nevada Test and Training Range were scheduled to expire in 2021; however, Congress is proposing to renew this land withdrawal for 25 years in the FY21 National Defense Authorization Act. The Department is supportive of ongoing efforts to retain this essential space to preserve our current capability to test and train.

If the available range space constrains our ability to accomplish the required open air testing, the Department may need to consider alternative methods that segment operational testing to fit within the available mission space, and/or becoming more dependent on M&S. Both these methods reduce the operational realism of full open-air testing and create other challenges in being able to validate these M&S.

Threats to Range Instrumentation

Some of the current range instrumentation rely on obsolete technology and software, increasing the risk of exploitation of sensitive information generated by weapon system testing. Adequate funding for range instrumentation modernization is required so instrumentation can be upgraded or replaced to standards that incorporate cybersecurity as a key performance parameter.

Persistent Surveillance

Foreign intelligence services are continuously attempting to conduct surveillance of U.S. weapon systems capabilities. One method of conducting this surveillance is through investing in U.S. entities adjacent to our test and training ranges. The Foreign Investment Risk Review Modernization Act (FIRRMA) of 2018 (part of the FY19 National Defense Authroization Act) provided several reforms to the Committee on Foreign Investment in the United States (CFIUS) process. It included a provision to assist in identifying real estate transactions posing a potential threat to national security through persistent surveillance of government activities conducting sensitive operations. Since its enactment, progress has been made working with the Services through the OSD Industrial Policy/Global Markets and Investments Office, the OSD participated in the Department of Treasury's rule making process to promulgate the FIRRMA regulations necessary to identify and mediate the transactions in proximity to sensitive test activities. In addition, the OSD provided a mapping capability shared across the DOD CFIUS process that rapidly mapped and identified potential proximity issues with real estate transactions. Based on the new rules, it is forecasted the case load will increase to approximately 1,000 per year over the next 2 years.

T&E Range Infrastructure Study

The NDS supports weapon systems developments that use a wide-range of new technologies such as directed energy weapons, hypersonic systems, autonomous systems, and artificial intelligence. Operational testing of capabilities that employ these new technologies will require modernizing our ranges, test infrastructure, and test capabilities. To assess current test capabilities and plan for the future, the National Academies of Science, Engineering, and Medicine (NASEM) is enlisting subject matter experts in land, sea, air, space and cyberspace warfighting domains from industry, academia and government, to assess the adequacy of range capabilities in the 2025-2035 time frame. DOT&E is sponsoring this study which is expected to complete in November 2021.

Joint Test and Evaluation

Joint Test and Evaluation

Joint Test and Evaluation (JT&E)

The primary objective of the Joint Test and Evaluation (JT&E) Program is to rapidly provide non-materiel solutions to operational deficiencies identified by the joint military community. The program achieves this objective by developing new tactics, techniques, and procedures (TTP) and rigorously measuring the extent to which their use improves operational outcomes. JT&E projects may develop products that have implications beyond TTP. Sponsoring organizations transition these products to the appropriate Service or Combatant Command (CCMD) and submit them as doctrine change requests. Products from JT&E projects have been incorporated into joint and multi-Service documents through the Joint Requirements Oversight Council process, Joint Staff doctrine updates, Service training centers, and coordination with the Air Land Sea Application Center. The JT&E Program also develops operational testing methods that have joint application. The program is complementary to, but not part of, the acquisition process.

The JT&E Program uses two test methods: the Joint Test and the Quick Reaction Test (QRT), which are all focused on the needs of operational forces. The Joint Test is, on average, a 2-year project preceded by a 6-month Joint Feasibility Study. A Joint Test involves an in-depth, methodical test and evaluation of issues and seeks to identify their solutions. DOT&E funds the sponsor-led test team, which provides the customer with periodic feedback and usable, interim test products. The JT&E Program normally charters two new Joint Tests annually.

The JT&E Program managed five Joint Tests in FY20 (those annotated with an asterisk (*) were completed in FY20):

- Joint Hypersonic Strike Planning, Execution, Command and Control (J-HyperSPEC2)*
- Joint Interoperability through Data Centricity (JI-DC)
- Joint Laser Systems Effectiveness (JLaSE)*
- Joint Sense and Warn (J-SAW)*
- Multi (enhanced) Domain Unified Situational Awareness (MeDUSA)*

QRTs are intended to solve urgent issues in less than a year. The JT&E Program managed nine QRTs in FY20 (those annotated with an asterisk (*) were completed in FY20):

- Integration of small Unmanned Aircraft Systems into Joint Airspace (sUAS)*
- Joint Aviation Multi-Ship Integrated Air Defense System (IADS) Survivability Validation (JAMSV)*
- Joint Chemical Biological Radiological Nuclear (CBRN) Tactical Information Management (J-CTIM)*
- Joint Enhanced Emissions Control (EMCON) Procedures (JEEP)*
- Joint Enterprise Data Interoperability (JEDI)*
- Joint/Interagency – Ground/Air Transponder Operational Risk Reduction (JI-GATOR)
- Joint Military Application of the Space Environment (J-MASE)*
- Joint Optimization of Electromagnetic Spectrum (EMS) Superiority (JOES)*
- Situational Positioning of Long Dwell, Long Duration (LD2) Intelligence, Surveillance, and Reconnaissance (ISR) – Concept of Operations (CONOPS) Evolution (SPLICE)*

As directed by DOT&E, the program also conducts Special Projects as a means of executing viable nominations that could not be resourced through the JT&E Program. The sponsor provides the resources to conduct the project following the guidelines of a Joint Test or QRT under the JT&E Program. Special Projects generally address emergent issues that are not addressed by any other DOD agency but that need a rigorously tested solution. The JT&E Program managed one Special Project in FY20:

- Joint Rapid Alerting for Survivability and Endurability (J-RASE)

JOINT TESTS

JOINT HYPERSONIC STRIKE PLANNING, EXECUTION, COMMAND AND CONTROL (J-HYPERSPEC2) (CLOSED SEPTEMBER 2020)

Sponsor/Start Date: U.S. Strategic Command (USSTRATCOM)/August 2018

Purpose: To develop, test, and evaluate command and control (C2) CONOPS that enables warfighters to effectively plan and support hypersonic weapon employment decision-making to fully capitalize on this emerging capability.

Background: Multiple CCMDs require a conventional, long-range standoff capability for holding high priority, heavily defended targets at risk. DOD identified hypersonic strike as a top research and development priority and is moving forward to field a mix of land-, sea-, and air-launched weapons. A flexible mix of capabilities will provide Combatant Commanders with persistent, visible, and credible strike options without crossing the nuclear threshold. To prepare for the deployment of hypersonic strike weapons (HSW), the J-HyperSPEC2 Joint Test is developing and testing the corresponding C2 CONOPS to leverage existing Combatant Commander decision-making processes and adapt standoff munitions planning practices to seamlessly integrate HSW options into the Joint Targeting Cycle.

Test Activity: In January 2020, J-HyperSPEC2 successfully executed Field Test (FT)-A at exercise Pacific Sentry 20-1/Global Lightning 20-1, which was distributed across Camp Smith and Joint Base Pearl Harbor-Hickam in Hawaii and USSTRATCOM in Nebraska. The coronavirus (COVID-19) pandemic response restrictions severely reduced or canceled theater sponsored exercises and travel leading to the loss of FT-B venues and a reduction in data collection. COVID-19 constraint mandates hindered the test's ability to interact and obtain additional CCMD warfighter input. As a result, the addition of various General Officer non-attributional interviews was needed to assist in CONOPS refinement.

Products/Benefits:
- CONOPS integrates HSW into the joint planning process and provides leadership with necessary information to make decisions that offer the highest probability of success
- CONOPS provides a Combatant Commander with the conceptual framework required when planning, directing, and employing HSW in support of strategic and operational objectives
- Enables effective employment of HSW to provide a highly responsive, long-range, conventional strike option for distant, defended, fleeting, and/or time-critical threats when other military options are denied access, not available, or not preferred

JOINT INTEROPERABILITY THROUGH DATA CENTRICITY (JI-DC)

Sponsor/Start Date: DOD Chief Information Officer/February 2019

Purpose: To develop, test, and evaluate non-materiel products to enable the employment of a data-centric environment for mission commanders at the operational and tactical levels to effectively collaborate and conduct operations with coalition and multi-national partners.

Background: CCMDs are limited in their ability to effectively plan and conduct operations with a dynamic set of coalition partners because they cannot share information easily and securely. CCMDs currently operate more than 40 mission partner networks – each with their own extensive resource requirements as well as constraints on information flow between the networks. A data-centric environment would consolidate operations onto one network using attribute-based access control software to enable authorized users to view and share information while limiting access to that information by unauthorized users on the same network. With U.S. Central Command (USCENTCOM) as the operational lead, the JI-DC Joint Test focuses on collapsing disparate networks – created to support individual missions – into a single SECRET Releasable network. Instead of network separation, JI-DC separates data at the individual object level.

Test Activity: In November 2019, JI-DC conducted FT-1 at USCENTCOM to test the effectiveness of the procedures for network administrators to establish and manage group and user permissions on the USCENTCOM developed Data-Centric System. The JI-DC Joint Test was able to show that the test procedures enabled dynamic collaboration with an evolving set of mission partners. FT-2A took place at globally distributed locations in June 2020 to test data sharing procedures and capabilities with warfighters and further test network administrator procedures in a simulated target development cycle using U.S. and coalition targeteers as participants. Due to COVID-19 travel restrictions, FT-2A participants and testers worked remotely across the globe using virtual desktops and screen sharing to conduct test trials and allow data collectors to observe.

Products/Benefits:
- Policy and procedures to implement a data-centric environment across all realms of operations that will foster faster and more efficient information flow, collaboration, allocation of resources, and decision-making with allies, partner nations, and U.S. interagency counterparts
- Procedures will employ data-centric technologies that modernize information sharing capabilities to enhance operational effectiveness, enable dynamic multi-national force deployment, and deepen alliances through interoperability
- Data centricity will reduce the need for multiple operational networks each with unique partner sharing policies resulting in reductions in hardware, software, infrastructure, people, and significant savings in information system costs
- Recommendations to evolve policies for information sharing that leverage current technologies

JOINT LASER SYSTEMS EFFECTIVENESS (JLASE) (CLOSED DECEMBER 2019)

Sponsor/Start Date: Naval Surface Warfare Center, Dahlgren Division/April 2017

Purpose: To develop and test targeting procedures that incorporate weaponeering, risk analysis, and mitigation capabilities into the Joint Targeting Cycle that support the operational employment of high energy laser (HEL) weapon systems.

Background: HEL weapon systems continue to make rapid strides in development and demonstrated capabilities to destroy, disable, and degrade threat systems, such as unmanned aircraft systems, small boats, mortars, vehicles, communications, and power generation equipment. The employment of HEL weapons requires a paradigm shift from traditional munitions employment procedures given that HEL weapons rely primarily upon delivering heat to a target surface for the time required to achieve the desired effect. In order to determine the appropriate irradiance and dwell time on a given target, HEL weaponeering requires more qualitative data on target surface composition.

Test Activity: The JLaSE Joint Test was comprised of two events, FT-A and FT-B. FT-A occurred in March 2019 at the Joint Staff J6, Command, Control, Communications, Computers, Cyber Assessments Division test enclaves in Suffolk, Virginia. The test team used a simulated operational environment to test the effectiveness of the TTP. Participants representing all Service components tested each DOT&E-assigned Use Case and associated engagement. In June 2019, the JLaSE team dispersed to select U.S. Indo-Pacific Command (USINDOPACOM) Headquarters locations to execute FT-B during a command post exercise. This event provided an opportunity for the team to collect data on the Use Cases and validate the effectiveness of the TTP in a realistic testing environment. FT-B required minimal scenario development because it leveraged existing exercise data and established supporting exercise material to provide operator validation of scenarios and targeting data and procedures.

Products/Benefits:

- TTP developed and tested for the integration of HEL systems into joint and Service operations to create battlespace effects in response to the commander's intent and end-state objectives
- Integrates HEL systems capabilities into Joint Targeting Cycle processes focusing on capabilities analysis for weaponeering and combat risk assessment
- Establishes increased confidence in warfare commanders to select HEL as a viable combat capability to employ scalable lethality effects ranging from degrading sensors to catastrophic destruction
- Development of HEL Joint Munitions Effectiveness Manual lethality data for weaponeers and target planners to determine laser weapons effects on targets
- Recommendations to assist the Services in HEL system development, acquisition, and integration as it applies to their operational employment procedures

JOINT SENSE AND WARN (J-SAW)
(CLOSED NOVEMBER 2019)

Sponsor/Start Date: U.S. Air Forces in Europe – Air Forces Africa and USINDOPACOM/August 2018

Purpose: To develop, test, and evaluate a concept of employment (CONEMP) and TTP to integrate a persistent surveillance system into existing U.S. and coalition IADS architecture for use in air defense warning and engagement C2.

Background: CCMDs require timely detection and warning of air and missile threats for friendly forces to react – both in peacetime and wartime. Reliable and redundant connectivity for communications and sensor systems is vital for accurate and timely warning. A combination of air-, space-, and surface-based detection and communication assets should be utilized to maximize detection and warning. To reduce the effectiveness of hostile air threats against friendly forces, U.S. European Command (USEUCOM) and other CCMDs are integrating new sensors into existing Integrated Air and Missile Defense (IAMD) architectures. The J-SAW Joint Test focused on (1) planning-execution-sustainment considerations and information exchange requirements needed for Air Defense, (2) USEUCOM and sensor unique TTP, and (3) training and reference guides to educate warfighters and leadership on Defensive Counter Air missions.

Test Activity: J-SAW conducted one risk reduction event and one field test to collect information and data related to CONEMP-TTP effectiveness when functioning in various operational environments. The field test allowed refinement and validation of the CONEMP-TTP based on findings and conclusions from analysis. The field test was broken into two parts. FT-A took place in conjunction with Astral Knight 2019 at Aviano Air Base, Italy, from June 3 – 6, 2019. It involved live sensors integrated into an IAMD architecture that detected and reported live air tracks simulating air and missile threats. FT-B was a constructive simulation event at the Warrior Preparation Center at Einsiedlerhof Air Station, Germany, from June 17 – 21, 2019. It consisted of C2 operators that monitored sensors and fed tracks of interest to a Fusion Cell in Phase 1 (deter) operations and a Control and Reporting Center in Phase 2 (seize initiative) operations.

Products/Benefits:

- CONEMP and TTP enable CCMDs to sense low-altitude air threats, integrate tracks into a theater common operational picture (COP), manage track identification and evaluation, and enable passive and active defense responses
- Improves air defense for U.S. and allied forces through earlier sensing and warning in both peacetime and wartime scenarios
- Integrates new sensor capabilities to better detect and track evolving air threats and provide increased response time for defense of critical military assets and warning to protected areas
- Provides a framework for integration of new sensors into existing IAMD architectures with recommended improvements in doctrine, organization, training, leadership, and education

MULTI (ENHANCED) DOMAIN UNIFIED SITUATIONAL AWARENESS (MEDUSA)
(CLOSED MAY 2020)

Sponsor/Start Date: USINDOPACOM and U.S. Northern Command (USNORTHCOM)/February 2018

Purpose: To develop, test, and evaluate non-materiel solutions for CCMDs and their various Service components to more effectively coordinate responses to operational or episodic events through increased situational awareness and understanding with unclassified COP information layers displayed together with classified information on the SIPRNET COP.

Background: In 2017, the Deputy SECDEF directed improvements to DOD Unclassified Shared Situational Awareness. This included tying existing systems together to form an unclassified COP and combining data and information into a synchronized picture to ensure timely and accurate information sharing. The directive from the Deputy SECDEF required USNORTHCOM and USINDOPACOM take the lead in managing and fusing geospatial data and information for use in the full range of military operations to include non-combatant evacuation operations, Defense Support of Civil Authorities, and humanitarian assistance and disaster response. This established a need for information to be generated in a standard displayable format that CCMDs can receive and display on their operational COP. The MeDUSA Joint Test developed a solution for the standardization and migration of unclassified information to the SIPRNET COP.

Test Activity: The MeDUSA Joint Test conducted two separate risk reduction events at USNORTHCOM and U.S. Southern Command (USSOUTHCOM) to exercise the steps of the draft Shared Situational Awareness Tactics, Techniques, and Procedures (SSA TTP) and observe data collection processes. FT-1 occurred in conjunction with USSOUTHCOM Integrated Advance 19. The test team evaluated the COP manager's ability to generate unclassified displayable products in the required formats, transfer those products from NIPRNET to SIPRNET, and display the products on the SIPRNET COP. Additionally, the MeDUSA Joint Test evaluated the level of enhanced situational awareness and understanding for decision-makers. FT-2 took place during USINDOPACOM Pacific Sentry 20-2 in January 2020. The event utilized CCMD and Service component staff planners, unclassified product developers, SIPRNET COP operators, and command decision-makers to test and evaluate the effectiveness and usefulness of a revised SSA TTP. A final version of the SSA TTP was produced and then transitioned to USINDOPACOM and USNORTHCOM as the product owners.

Products/Benefits: The SSA TTP was evaluated as strongly enabling the processes to generate standardized products and display the products on the SIPRNET COP to enhance both situational awareness and understanding. Operational users of the SSA TTP evaluated it as "Very Useful" to the warfighter. The procedures have been of benefit for DOD tracking and response to COVID-19 while coordinating efforts with non-military U.S. Government agencies, other non-government organizations, multi-national partners, and/or private sector entities that mainly operate in an unclassified information environment. Other benefits include:

- Validated technical processes and procedures for generating standardized unclassified domain products and displaying them on a SIPRNET COP to enhance commanders' situational awareness and understanding within their areas of responsibility
- Best practices and lessons learned for gaining situational awareness utilizing unclassified COP information on a consolidated SIPRNET COP
- Increased situational awareness and understanding through the use of an enhanced comprehensive view of data on a single COP

QUICK REACTION TESTS

INTEGRATION OF SMALL UNMANNED AIRCRAFT SYSTEMS INTO JOINT AIRSPACE (SUAS)
(CLOSED AUGUST 2020)

Sponsor/Start Date: Marine Operational Test and Evaluation Squadron One/March 2019

Purpose: To research, develop, and evaluate newly created airspace control TTP to allow sUAS to be integrated into joint airspace. The test focused on meeting the warfighter's requirements by capitalizing on the sUAS's unique capabilities, maximizing freedom of maneuver, and maximizing tactical contributions while balancing the need for safe integration.

Background: Current airspace control procedures and coordination methods do not adequately provide airspace planners, C2 personnel, and airspace users with the adequate TTP to effectively integrate sUAS into the joint airspace on a large scale.

Test Activity: The sUAS QRT included two separate test events conducted near Yuma, Arizona. In December 2019, the test team executed Test Event (TE)-1, which focused on sUAS corridors and integration with manned aircraft at terminal airspace locations, such as a Helicopter Landing Zone. TE-2 focused on testing the TTP related to integration of sUAS during manned aircraft weapons delivery, long range flight corridors, and C2 of sUAS operations. Due to COVID-19 constraints, TE-2 was a scaled down event conducted with a reduced capacity in May 2020. The contract test team and members of Marine Corps Warfighting Laboratory in Quantico, Virginia, and joint participants from the 5th Special Forces Group, U.S. Army, were not able to attend as a result of DOD travel restrictions. COVID-19 challenges in Yuma, Arizona, also required the team to delay selected analysis activities and deliverables.

Products/Benefits:
- Tactical Standard Operating Procedure (TACSOP) manual for the Marine Air Command and Control System to integrate sUAS into their airspace
- TACSOP will serve as the basis to establish joint sUAS integration TTP practices

JOINT AVIATION MULTI-SHIP INTEGRATED AIR DEFENSE SYSTEM (IADS) SURVIVABILITY VALIDATION (JAMSV)
(CLOSED JULY 2020)

Sponsor/Start Date: U.S. Army Aviation Center of Excellence/ October 2018

Purpose: To develop and assess rotary-wing multi-ship TTP utilizing joint, large scale combat operations missions and profiles to defeat anti-access/area denial (A2/AD) and radio frequency (RF) IADS threats.

Background: Limited empirical multi-ship and multi-threat testing data exist to validate aircraft survivability combined with accepted TTP against peer and near-peer adversary's IADS threat systems.

Test Activity: The test team executed engineering, test, and analysis support to develop and evaluate TTP for the joint rotary-wing community. Testing provided validation data for Multi-Ship Large Scale Combat Operations survivability effectiveness against advanced peer and near-peer IADS threats utilizing fielded aircraft survivability equipment. The JAMSV QRT field test was delayed almost 5 months due to an earthquake, which required recalibration of all test equipment and a new tasking for a supporting unit from U.S. Army Forces Command. As a result, FT-1 execution moved from August 2019 to January 2020. Later, COVID-19 restricted work capabilities during FT-1 data analysis and limited access to facilities to no more than two personnel at a time from March through July 2020. Even though the team used parallel efforts at different locations to maximize contractor support, a 60-day extension was required to incorporate test data into the TTP for 3900 Series tasks (Aviation Mission Survivability collective training tasks), a maneuver handbook, and final report. With the extension, the test team completed all test analysis and transitioned the TTP and maneuver handbook.

Products/Benefits:
- Validated rotary-wing multi-ship TTP to defeat A2/AD and RF IADS threats
- Acquired high-fidelity data for future use in modeling and simulation for further TTP development and optimization
- Updated and developed TTP for 3900 Series tasks, a maneuver handbook, and training support package
- Informed aircraft survivability equipment modernization and shaped requirements for future systems

JOINT CHEMICAL BIOLOGICAL RADIOLOGICAL NUCLEAR (CBRN) TACTICAL INFORMATION MANAGEMENT (J-CTIM)
(CLOSED DECEMBER 2019)

Sponsor/Start Date: USINDOPACOM/June 2018

Purpose: To identify gaps in current chemical, biological, radiological, and nuclear (CBRN) early warning and reporting processes and develop improved TTP for timely and effective protective posture decision support to friendly forces that enables continuity of operations under situations involving CBRN threats.

Background: DOD lacked standard tested and validated TTP for effective joint warning and reporting in the lead up to a CBRN incident, especially at the tactical level. In addition, Land Maneuver Commanders lacked the ability to make proactive risk-based decisions in a complex CBRN environment. The intelligence community further forecasted an uncertain and rapidly changing world in which the CBRN danger increases in both scope and scale – primarily due to behaviors of multiple networks of actors who seek, possess, and proliferate CBRN materials.

Test Activity: In September 2019, the test team executed TE-2 as a staff exercise in the Digital Training Facility at the Maneuver Support Center of Excellence at Fort Leonard Wood, Missouri. TE-2 used a two-group experiment model in a controlled constructive simulation to collect data and retest the baseline information requirements and priority intelligence requirements list of indicators from TE-1. The event demonstrated a means by which to exploit information and situational dominance through improved situational understanding of this complex environment.

Products/Benefits:
- TTP supports the joint community to conduct early detection of CBRN agents within the tactical environment
- TTP provides warfighters across all Services with the ability to quickly react to a CBRN attack and reduce its effects
- TTP improves the use of information requirement's development as a link in the development of a functionally integrated CBRN framework

JOINT ENHANCED EMISSIONS CONTROL (EMCON) PROCEDURES (JEEP)
(CLOSED NOVEMBER 2019)

Sponsor/Start Date: Naval Information Warfighting Development Center/June 2018

Purpose: To develop TTP to mitigate friendly systems vulnerabilities through determining which friendly RF emissions are detectable by adversary signals intelligence capabilities.

Background: EMCON is a significant concern for joint forces. Detection can leave the emitting force in a position of tactical disadvantage, especially if the detection leads to their geolocation by an adversary. As many potential adversaries field long-range signals intelligence capabilities, it is critical for joint forces to understand and manage their RF emissions.

Test Activity: The test team conducted a three-phased field test over a period of approximately 5 weeks from August through September 2019. Each phase included a scenario that directed operators to use their equipment or system in a manner consistent with the TTP. Phase 1 was a land-based test with Marine Corps systems at Marine Corps Air Station Cherry Point, North Carolina. Phase 2 consisted of a maritime test aboard USS *John C. Stennis* (CVN 74) in Norfolk, Virginia, with a focus on maritime RF emitters. Phase 3 was a land-based test with the U.S. Army during exercise Cyber Blitz at Fort Dix, New Jersey, with a focus on ground-based RF emitters.

Products/Benefits: TTP that includes a matrix for tactical-level guidance that allows friendly forces to better understand the probability that their RF emissions will be detected by an adversary and what information an adversary will likely be able to derive.

JOINT ENTERPRISE DATA INTEROPERABILITY (JEDI) (CLOSED DECEMBER 2019)

Sponsor/Start Date: Department of the Army G-4/March 2018

Purpose: To develop a validated CONOPS to implement logistics data exchange standards among partners required for the Joint Logistics Enterprise to support Globally Integrated Operations as identified in the Chairman, Joint Chiefs of Staff Joint Concept for Logistics, and the Capstone Concept for Joint Operations: Joint Force 2020.

Background: The overall problem examined by the JEDI QRT was the inability for sharing logistics data between the Services, joint organizations, and non-DOD partners. Non-materiel solutions are necessary to implement joint enterprise data interoperability and USEUCOM Mission Partner Environment – Information System capabilities within Service and joint organizations to enhance mutual logistics support across joint and combined operations.

Test Activity: The majority of the JEDI QRT testing was conducted in September 2019 during a field test table top exercise (TTX), which included participants at Fort Belvoir, Virginia, and other remote sites. The distributed method of the test allowed the team to reach a broader, global audience. During the event, the team briefed participants on the three functional areas of the JEDI CONOPS and provided correlated scenarios to demonstrate how the CONOPS could be operationalized. At the conclusion, test participants completed surveys and data collection forms, which the team used to evaluate the JEDI CONOPS.

Products/Benefits:

- CONOPS and Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy change recommendations that addressed logistics information sharing between the U.S. and multi-national forces
- CONOPS that enhanced logistical interoperability with an allied partner (United Kingdom) and provided a greater level of sustainment to forces embedded within the ranks of a U.S. division
- CONOPS provides a mechanism for extraction of logistics data from national systems to a multi-national system within the Logistics Functional Area Services system to enhance the logistics COP across all levels of commands

JOINT/INTERAGENCY – GROUND/AIR TRANSPONDER OPERATIONAL RISK REDUCTION (JI-GATOR)

Sponsor/Start Date: Headquarters, U.S. Air Force A3 and North American Aerospace Defense Command – USNORTHCOM/June 2019

Purpose: To develop, test, and validate joint and interagency TTP packages to mitigate aviation transponder vulnerabilities. In addition, the resulting test data will help inform policy, rulemaking, training, and regulations to allow for the appropriate employment of TTP anywhere in the aviation ecosystem.

Background: Across aviation and ground-based services, multiple transponder systems broadcast data in the clear that commercial services can collect and display to any end user. Many of these systems are now required to be used by all aircraft. Automatic Dependent Surveillance-Broadcast (ADS-B), a supplement to traditional air field radars, was mandated for use by 2020 in the United States and Europe. Today, aviation is dependent on broadcast modes such as ADS-B for navigation, air traffic control, and flight safety. Operational security is compromised by the distinct lack of confidentiality of data transmitted by these modes.

Test Activity: Field test events took place between May and July 2020. The test team used an innovative "Virtual Test in the Cloud" data collection process to overcome challenges from COVID-19 restrictions. Most of the test team had limited to no access to the planned test sites and completed their roles from a combination of home and government offices scattered across the country. All test aircraft flew from their home stations with no collocation deployments of team members and aircraft as originally planned. The "Virtual Test in the Cloud" used virtual private networks, cloud storage, teleconference and video-teleconference networks, a detailed playbook, and a regularly updated and distributed Air/Ground Test Point Scoreboard that allowed the test team to collaboratively kick-off and control each day's events. The Ground TTP testing using Federal Aviation Administration automation systems was severely limited due to COVID-19. Analysis of the ground data is still being evaluated.

Products/Benefits:

- TTP to mitigate aviation transponder data confidentiality, integrity, and availability vulnerabilities affecting operational security, air traffic control, and air surveillance missions on the ground and in the air
- TTP to enable operators to configure their systems to restrict unwanted transponder emissions/tracks, interpret the data in the air traffic control environment, and use this data to achieve desired effects
- TTP to address the differences between air traffic control system hardware configurations in DOD and interagency aircraft in varied real-world air traffic control environments

JOINT MILITARY APPLICATION OF THE SPACE ENVIRONMENT (J-MASE) (CLOSED JULY 2020)

Sponsor/Start Date: Space and Missile Systems Center and USINDOPACOM/March 2019

Purpose: To develop, test, and validate standardized TTP for the use of Military Application of the Space Environment (MASE) decision aids during operational- and tactical-level mission planning and execution, providing a repeatable and scalable methodology for countering long-range threats.

Background: The MASE Joint Capability Technology Demonstration delivered a mission support capability resulting in an informal TTP for limited operational use to increase warfighter situational awareness of adversary Over the Horizon Radars probability of detection. However, additional TTP development and validation through a formal test and evaluation were still required for formal documentation and future applications.

Test Activity: COVID-19 response measures disrupted field test activities scheduled for March through May 2020. As a result, the planned field tests were replaced with limited remote testing. During FT-2/Air TTX, the ability of test participants to complete record runs depended on variable work schedules. Participants from the 96th Bomb Squadron at Barksdale AFB continued to conduct TTP operational planning during quarantine to provide record run data for FT-2/Air TTX. The 82nd Reconnaissance Squadron from Kadena Air Base and the 55th ISR Wing from Offutt AFB separately conducted elements of the airborne TTP execution. To execute FT-2/Maritime TTX, the team reached out to the USS *Grace Hopper* (DDG-70) and the USS *Curtis Wilber* (DDG-54) in the USINDOPACOM area of responsibility. Through secure communications, the team observed operational units employ the tool in real time during real-world missions. FT-2 concluded with the test team executing both Air record runs and Maritime TTX with excellent cooperation and participation from multiple geographically separated organizations.

Products/Benefits:

- Validated TTP utilizing MASE applications
- Enhanced decision-making tools to be used during operational and tactical planning
- Enhanced freedom of maneuver and survivability tools for air and maritime assets

JOINT OPTIMIZATION OF ELECTROMAGNETIC SPECTRUM (EMS) SUPERIORITY (JOES)
(CLOSED NOVEMBER 2019)

Sponsor/Start Date: USINDOPACOM/June 2018

Purpose: To develop TTP for the integration of joint electromagnetic spectrum operations (JEMSO) functions into a standing JEMSO Cell for CCMD's effective use of EMS for assured friendly C2 and to degrade adversary capabilities.

Background: To enable joint force commanders to gain tactical, operational, and strategic advantage against near-peer adversaries, the joint warfighter must win the fight for EMS superiority. Operations within the air, land, sea, space, and cyberspace domains are similar in their EMS-dependence. In fact, EMS is the only physical space shared by every warfighter. JEMSO Cells at the CCMDs provide the processes and focus to effectively prioritize, integrate, synchronize, and deconflict the EMS aspects of operations throughout the operational environment. U.S. platforms and weapon systems rely on EMS – a reliance increasingly challenged by competitors and adversaries.

Test Activity: In August 2019, the test team conducted FT-2 TTP Validation Event (VE) at the Joint Electromagnetic Warfighting Center in San Antonio, Texas. This event allowed the team to validate key areas of the TTP that could not be tested during FT-1 where a functional JEMSO Cell participated in Pacific Sentry 19-3. FT-2 TTP VE was comprised of three portions of the JEMSO process: component EMS operations planning, JEMSO Working Group, and JEMSO Cell planning. During the event, the test team guided and observed the functions of the JEMSO Cell planning cycle, and then administered short surveys to both the component EMS operations planners and the JEMSO Cell participants.

Products/Benefits: TTP to support JEMSO Cell functions to develop an EMS superiority strategy, mitigate adversary's abilities to contest friendly operations, coordinate authorizations for friendly forces, and tailor EMS signatures to limit friendly vulnerabilities.

SITUATIONAL POSITIONING OF LONG DWELL, LONG DURATION (LD2) INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (ISR) – CONCEPT OF OPERATIONS (CONOPS) EVOLUTION (SPLICE)
(CLOSED JUNE 2020)

Sponsor/Start Date: USSOUTHCOM/October 2018

Purpose: To develop TTP and Contingency Operations CONOPS for selecting and setting the initial deployment locations and waypoints of LD2 assets using the LD2 mission management module; executing thin line C2 positioning and navigation of LD2 assets during operations based on real-world conditions and other Joint Interagency Task Force South (JIATF-S) reporting; and deconflicting and executing tasking of unallocated LD2 sensor times.

Background: The LD2 program was developed to address how limited in-theater ISR assets and coverage of maritime trafficking routes can be engaged to enhance USSOUTHCOM and its partner nations' ability to detect, monitor, exploit, and fully illuminate threat networks. The concept employs systems in near space, airspace, and sea surface working in concert to provide a unified tipping and cueing architecture to vastly expand ISR coverage. The program leverages traditional national and tactical ISR capabilities only. The innovative and contractor-owned, contractor-operated nature of LD2 limits its ability to effectively integrate with existing DOD mission command and ISR frameworks. USSOUTHCOM and JIATF-S lacked the CONOPS and TTP to fully evolve and integrate traditional and non-traditional LD2 assets into a persistent surveillance capability. This has limited the ability to provide a high-performance, persistent surveillance capability across a large coverage area to support USSOUTHCOM's detection and monitoring mission against illicit drug trafficking.

Test Activity: In March 2020, COVID-19 restrictions went into effect as the test team was about to conduct their final test event. The resulting disruptions to work capabilities hindered operations during TE-2 execution and data analysis. With limited access to facilities, the team employed parallel efforts in multiple locations to maximize contractor support. Despite making significant progress in meeting test plan goals, the team required an extension to incorporate TE-2 data into the CONOPS and TTP, complete the final report, and transition the test products to JIATF-S.

Products/Benefits:

- TTP will contribute to the critical USSOUTHCOM mission set: detection and monitoring of surface and sub-surface targets of interest engaged in the trafficking of illegal commodities for U.S. and partner nation interdiction and apprehension
- CONOPS and TTP helped set the conditions for the successful phase-in transition of commercial, autonomous LD2 ISR assets into the USSOUTHCOM area of responsibility during the next 3 years to support the detection and monitoring mission

---

SPECIAL PROJECTS

JOINT – RAPID ALERTING FOR SURVIVABILITY AND ENDURABILITY (J-RASE)

Sponsor/Start Date: USSTRATCOM/October 2019

Purpose: To develop operationally realistic processes for strategic-to-tactical notifications and tactical-to-strategic status report-back of information to improve the management of strategic command, control, and communications (C3) and logistics processes in a degraded, contested communications environment.

Background: Executive Order 13865, "Coordinating National Resilience to Electromagnetic Pulses," issued on March 26, 2019, directs a whole-of-government response to electromagnetic pulse (EMP), which is an evolving threat to critical infrastructure to include strategic C3 systems. The previous Joint Pre-/Post-Attack Operations Supporting Survivability and Endurability (J-POSSE) Joint Test emphasized the need for timely notification and protective procedures to prevent damage to critical C3 systems. Building on those findings, the J-RASE Special Project extends beyond the immediate effects of a catastrophic event to provide solutions for the enterprise to endure and sustain operations that support the deterrent capability of the joint force.

Test Activity: In December 2019, J-RASE conducted both a TTP Working Group meeting in Colorado Springs, Colorado, and a Joint Warfighter Advisory Group meeting at Joint Test Unit – Suffolk, Virginia. J-RASE also held a TTP Development Event during exercise Global Lightning 2020 in January 2020. Beginning in March 2020, COVID-19 hindered operational user familiarization efforts due to travel restrictions, halted work due to lack of access to secure workspaces, and caused the cancellation of the risk reduction event originally scheduled in May 2020. The test team conducted the rescheduled risk reduction event in July 2020. The team followed up that event with a High Frequency test, which was delayed to September 2020 due to equipment fielding. The High Frequency test ensures locations are capable of having adequate and reliable equipment with transmissions that can operate in a degraded environment and that operators are versed in using system redundant communications. Both events served to prepare the team for the field test planned for October 2020 during exercise Global Thunder 2021. Continued setbacks from the pandemic, equipment fielding, and delayed testing and findings determination meant that not all project objectives could be accomplished within the single field test as originally planned. Another field test and subsequent funding to cover a 3-month extension and communications challenges are being addressed.

Products/Benefits:

- Procedures for rapid notification of forces and supporting agencies to initiate actions to enhance the survivability of their C3 systems and manage their unit's capability to endure and sustain operations in a degraded, contested communications environment
- Improves the joint warfighters' ability to rapidly prepare for an attack, initiate protective measures, recover smartly, sustain, and endure while continuing to meet current operational requirements

Center for Countermeasures

Center for Countermeasures

The Center for Countermeasures (CCM)

The Center for Countermeasures (the Center) is a joint activity that directs, coordinates, supports, and conducts independent countermeasure/counter-countermeasure (CM/CCM) T&E activities of U.S. and foreign weapons systems, subsystems, sensors, and related components. The Center accomplishes this work in support of DOT&E, weapon systems developers, and the Services. The Center's testing and analyses directly support evaluations of the operational effectiveness and suitability of CM/CCM systems.

Specifically, the Center:

- Determines the performance and limitations of missile warning and aircraft survivability equipment (ASE) used on rotary- and fixed-wing aircraft
- Provides T&E support to Program Offices for the rapid development and deployment of directed energy weapons (DEW)
- Supports the development of DEW test instrumentation
- Operates unique, portable test equipment that supports testing across the DOD
- Develops and evaluates CM/CCM techniques and devices
- Provides analyses and recommendations on CM/CCM effectiveness
- Supports Service exercises, training, and pre-deployment activities

The Center conducts these activities — from testing and analysis of CM/CCM systems, to support training and pre-deployment activities, and development of CM/CCM tools and techniques — to enhance and support the survivability of equipment, aircraft, and personnel. The Center's core mission to support T&E of ASE directly leads to a "more lethal force" by enabling the survivability of aircraft in a high threat environment. Survivability enables mission success. This fiscal year, the Center expanded its test support of DEW used for Counter-Unmanned Aircraft Systems (C-UAS) and base defense, and it was involved in the development of three new DEW test resources.

The Center completed 29 T&E activities in FY20. The coronavirus (COVID-19) pandemic affected the Center's T&E activities during the last 6 months of FY20, which spanned the spring and summer, the busiest time of the year for T&E activities. Had COVID-19 not affected the schedule, the Center was on track to meet or exceed the 45 T&E activities it had completed the previous fiscal year. However, in coordination with DOT&E and with careful planning to ensure the safety of Center and on-site test personnel, the Center completed 13 of its total T&E activities during this challenging time. The majority of the Center's T&E efforts focused on Joint Urgent Operational Needs Statement (JUONS) programs in support of ASE activities. The Center's involvement in JUONS testing helped fulfill immediate mission needs that resulted in the successful deployment of critical equipment to combat theaters. In FY20, the Center increased its participation in DEW T&E activities, sending its engineers and scientists to assist program offices with data collection, reduction, and analysis, as well as providing its custom test instrumentation and equipment to collect data. The Center also provided realistic man-portable air-defense system (MANPADS) and radio frequency (RF) threat simulators to create high-threat environments for Service aircrew pre-deployment training. In the course of these activities, the Center conducted the test support and analysis of more than 33 DOD systems or subsystems and reported the results. The Center also provided subject matter experts (SMEs) to working groups, task forces, and program offices. While conducting its test activities, the Center continues to improve its T&E capabilities and test methodologies.

DEW AND C-UAS TEST ACTIVITIES

Mobile High Energy Laser Measurement (MHELM) Tests

- **Sponsor:** Test Resource Management Center (TRMC) and Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI)
- **Tests:**
  - MHELM Cruise Missile Electro-Optics (CaMEO) Target Board (TB) Static Test (September 30 to October 10, 2019), High Energy Laser Systems Test Facility (HELSTF), White Sands Missile Range (WSMR), New Mexico
  - MHELM small Unmanned Aircraft System (sUAS) Static Test (October 21 – 23, 2019), HELSTF, WSMR, New Mexico
  - MHELM sUAS Phase 1 Static Follow-on Test (November 18, 2019), HELSTF, WSMR, New Mexico
  - MHELM sUAS Track Illuminator Laser Illumination Test (December 4, 2019), HELSTF, WSMR, New Mexico
  - MHELM CaMEO Pod 3 and 4 Ground Test (February 24 – 25, 2020), HELSTF, WSMR, New Mexico
  - MHELM sUAS Ground Test Phase 2 (February 26 – 28, 2020), HELSTF, WSMR, New Mexico
  - MHELM sUAS Flight Test (September 8 – 18, 2020), HELSTF, WSMR, New Mexico
- **Activity/Benefit:** TRMC is developing MHELM, which is a family of DEW instrumentation that will characterize

high-energy laser (HEL) and high-power microwave weapon performance. The MHELM instrumentation is expected to support upcoming U.S. Navy Solid State Laser Technology Maturation Laser Weapon System Demonstrator and HEL & Integrated Optical Dazzler with Surveillance systems. The Center, in partnership with HELSTF, assisted with test planning and setup; operated a HEL system surrogate and beam diagnostic recorders; and reduced data in support of the verification and validation testing for the CaMEO and sUAS TBs. The subsonic CaMEO and sUAS TBs are expected to provide HEL spot measurements (total power on target, beam center position, beam spread/shape, derived beam irradiance, and beam jitter/walk) on an inflight, operationally representative cruise missile and Group-1 unmanned aerial vehicle targets. The CaMEO and sUAS are being developed under the MHELM portfolio, which the TRMC Central T&E Investment Program (CTEIP) funds and PEO STRI executes.

C-UAS Tests

- **Sponsor:** Defense Threat Reduction Agency, Research and Development Directorate, Threat Technology Department
- **Tests:**
  - Counter Drone II (October 21 to November 14, 2019), WSMR, New Mexico
  - Apollyon 2020 (August 10 – 21, 2020), Eglin AFB, Florida
- **Activity/Benefit:** Center personnel, in partnership with the White Sands Test Center, conducted the Counter Drone II test to evaluate the maturity and current capabilities of commercial off-the-shelf (COTS) C-UAS systems and to determine how well COTS C-UASs effectively neutralize sUAS threats. The Center also collected data, conducted an analysis, and reported the results. During Apollyon 2020, the Center collected data and assembled the sUASs to assess current, commercial, counter drone system-of-systems testing and counter drone system testing. The commercial test asset included communication augmentation systems, acquisition and tracking radars, electro-optical (EO) tracking camera systems, and high-power microwave systems.

ASE JUONS TEST ACTIVITIES

Army: Advanced Threat Warner (ATW) and Common Infrared Countermeasures (CIRCM) Tests

- **Sponsor:** U.S. Army Technology Applications Program Office (TAPO) and the 160th Special Operations Aviation Regiment (SOAR) Systems Integration and Maintenance Office (SIMO)
- **Tests:**
  - ATW and CIRCM MH-47G Test (February 27 – 29, 2020), Redstone Arsenal, Alabama
  - ATW and CIRCM MH-47G Test (September 21 – 25, 2020), Redstone Arsenal, Alabama
- **Activity/Benefit:** The Center provided one Joint Mobile Infrared Countermeasure Test System (JMITS) for simultaneous, two-color infrared (IR) missile plume simulations and jam beam data collection. The IR simulations elicited a response from the ATW and provided an IR source for the CIRCM to track; the jam beam radiometers (centerline and outer) characterized the CIRCM jam return. The Center's simulator conducted single threat engagements during both tests, and the Center provided near real-time feedback on missile plume simulation quality and jam beam data. The Center collected data and assessed the ATW's ability to detect and declare threats and provide a handoff to the CIRCM, CIRCM's ability to put energy on the threat, and characterized CIRCM jitter and bias. The Center's assessment helped TAPO/SIMO evaluate the integrated ATW/CIRCM system, as installed on the MH-47G, and determine its readiness for fielding. Center participation in these tests was in direct support of ongoing TAPO ATW JUONS efforts to increase aircraft protection for the MH-47G against IR-guided threats.

Navy: Distributed Aperture Infrared Countermeasure (DAIRCM) Tests

- **Sponsor:** PEO, Tactical Aircraft Programs (PMA-272) on behalf of the Detachment 1, 413th Flight Test Squadron, TAPO, and 160th SOAR SIMO
- **Tests:**
  - MH-60S, AH-1Z IT-2.2 Phase 1 (September 19 to October 11, 2019), Eglin AFB, Florida
  - MH-60S (February 24 to March 4, 2020), Webster Field, Maryland
  - UH-1Y (June 6 – 9, 2020), Webster Field, Maryland
  - HH-60G Pave Hawk Section, Air Force Life Cycle Management Center (July 7 – 17, 2020), Nellis AFB, Nevada
  - MH-6M TAPO JUONS (August 24 – 28, 2020), Redstone Arsenal, Alabama
- **Activity/Benefit:** The Center provided one JMITS with four MANPADS threat seekers, one Multi-Spectral Sea and Land Target Simulator (MSALTS), and three threat-representative lasers for the IT-2.2 phase of the DAIRCM. The Center provided one MSALTS and three threat-representative lasers for the HH-60G testing and one MSALTS for all other phases of testing. The simulators provided the two-color IR missile plume simulations and jam beam data collection capability required to assess the DAIRCM missile warning system's (MWS) ability to detect and declare the threat and the DAIRCM directed infrared countermeasure's (DIRCM) ability to acquire, track, and put laser energy on the target. Center analysts used the threat-representative lasers to assess

the DAIRCM laser warning system's (LWS) ability to detect and declare laser threats. The Center's assessment helped PMA-272, DAIRCM developers, and stakeholders assess DAIRCM MWS, LWS, and DIRCM capabilities. Based on data from these tests, the DAIRCM hardware and software were upgraded, as needed, to improve the MWS, LWS, and DIRCM performance; improve aircrew situational awareness messaging traffic for audio alerts; and improve the display of threat location and CM employed on the control user interface. The Center's participation in these tests was in direct support of ongoing PMA-272 and TAPO JUONS efforts to improve aircraft protection of tactical rotary-wing platforms against IR-guided threats.

Air Force: AC-130J JUONS and Combat Mission Need Statement (CMNS) Large Aircraft IR Countermeasures (LAIRCM) Flight Test

- **Sponsor:** U.S. Department of the Air Force, Air Force Special Operations Command (AFSOC)
- **Test:** AC-130J (July 13 – 17, 2020), Eglin AFB, Florida
- **Activity/Benefit:** The purpose of the test was to evaluate the upgrade on the AC-130J from the AN/AAQ-24(V) LAIRCM system to ATW sensors, Guardian Laser Transmitter Assembly (GLTA), and a new processor to improve aircraft survivability in a high-threat environment. The Center provided one JMITS, one moving MSALTS, and one laser beamrider for single, dual, and multi-threat engagements against the AC-130J. The IR simulations elicited a response from the ATW and provided an IR source for the GLTA to track; the jam beam radiometers characterized the GLTA jam return. The Center collected data to assess the ATW MWS's ability to detect and declare threats and provide a handoff to the GLTA; to assess the GLTA's ability to put energy on the threat; and to assess the ATW LWS's ability to detect and declare laser threats. Center participation in this test was in direct support of ongoing AFSOC JUONS and CMNS efforts. The Center's assessment helped AFSOC evaluate the integrated ATW/GLTA, as installed on the AC-130J, and determine its readiness for fielding in theatre.

TRAINING SUPPORT FOR SERVICE EXERCISES

- **Exercise:** Joint Aviation Multi-Ship Integrated Air Defense System (IADS) Survivability Validation Quick Reaction Test (January 20 – 31, 2020), China Lake Naval Weapons Center, California
- **Activity/Benefit:** The Center provided realistic MANPADS threat environments used to train pilots and crew and give them a better understanding of ASE equipment and its use. Specifically, the Center provided an MSALTS and the MANPADS Technical to simulate a specific threat environment for participating aircraft. The Center also provided SME support to observe aircraft ASE systems and crew reactions to the threat environment. At the end of each exercise, the Center's SME presented MANPADS capabilities and limitations briefings to the pilots and crews, and at the end of the briefings, allowed them to hold and manipulate the specific MANPADS. The data the Center collected and provided to the trainers/testers helped the units develop and refine their tactics, techniques, and procedures to enhance survivability in a combat environment.

- **Exercise:** U.S. Army Special Operations Aviation Command, Special Operation Aviation–Advance Tactics Training (August 3 – 11, 2020), China Lake Naval Weapons Center, California
- **Activity/Benefit:** The Center supported this joint training exercise, which the 160th SOAR conducted, for pre-deployment training of aircrews and staff in a realistic, contested, near-peer threat environment. The Center provided an MSALTS to simulate the threat environment for participating aircraft. The Center also provided SME support to observe aircraft ASE systems and crew reactions to the threat environment. The 160th SOAR and AFSOC aircrews flew aircraft equipped with the latest infrared countermeasure technology on a high fidelity, electronic combat range. Aircrews conducted training with CMWS, AAQ-24, and AAQ-45. Aircrews will complete New Equipment Training and operational validation of the AAQ-45.

T&E TOOLS

The Center continues to develop tools for T&E of DEW and ASE, and deploy its personnel and specialized T&E tools throughout the country. The Center takes its T&E tools to the Services, providing them with cost-effective test support to collect critical data needed to assess the performance of their CM/CCM systems. In addition, the Center supports the Service's ASE programs with its unique test equipment, which reduces duplicative T&E capabilities. This benefit, along with the transportability of the Center's unique test equipment, provides the DOD a cost savings that results in "greater performance and affordability." The Center is constantly collaborating with the various entities within the T&E community to identify and solve shortfalls in the T&E infrastructure in support of the National Defense Strategy.

The Center is a permanent member of the TRMC Directed Energy Instrumentation Initiative review panel. PEO STRI chairs this panel and serves as its executive agent for testing of Services rapid prototyping and fielding. The Center is actively engaged in building partnerships and providing the DEW community its expertise from a DOT&E perspective.

HEL Remote Target Scoring (HRTS)
HRTS addresses a capability gap in HEL target scoring in operationally realistic environments. PEO STRI and the Center are leading the development of the HRTS system under the Directed Energy Instrumentation Initiative portfolio funded in 2019 through a congressional plus-up. The HRTS will have the capability to evaluate the effectiveness of tri-service HEL weapon systems on land and in maritime environments. The HRTS system will integrate a sensor suite onto a Kineto-Tracking Mount to track, image, score, and provide Time-Space-Position Information from a mobile/transportable, remotely operated platform during HEL engagements. This capability will enable the tracking and scoring of a variety of targets during HEL engagements, including light boats, rocket-artillery-mortars, UAS, and subsonic and supersonic cruise missiles. Additionally, the Center has identified both common HRTS hardware and capabilities for possible use and integration with other Center activities and T&E tools, including the JSIS. The HRTS system will extend Center and WSMR testing capabilities with two deliverable systems that can operate in various T&E environments. The HRTS contract was awarded in FY20, and HRTS successfully went through the Preliminary Design Review conducted in June 2020. The HRTS system is currently expected to be available for use by all Services in 4QFY21.

Beam Characterization Sensor Suite (BCSS)
The Center is developing the BCSS, which is an integrated sensor suite with associated computing hardware that gives HEL beam and target characterization capabilities of static targets. The BCSS beam measuring capability will help HEL programs determine laser beam characteristics on static targets prior to engaging costlier operational targets. The BCSS target characterization capability will provide calibrated imagery and radiometry to support lethality and survivability testing. The BCSS IOC, which is currently under development, will provide a baseline of overall intended capability. In its full operational capability (FOC), the BCSS is expected to incorporate direct power measurements and expanded calibrated imagery capabilities. The BCSS IOC is expected in 1QFY21 and FOC configuration is expected in 4QFY21.

Gyro-Stabilized Tracking Mount (GSTM)
The objective of the GSTM is to provide a low footprint, point and track sensor solution for ship-based HEL weapon system T&E. Specifically, the GSTM will be used to point the receiving end of the Differential Image Motion Monitor and Wide Angle Tele-radiometric Transmissometer atmospheric path sensors while performing a stabilized track of aerial targets and munitions from a sea-based platform. The Center partnered with the Naval Air Warfare Center Weapons Division in the development and procurement of the GSTM, leveraging their T&E expertise and developmental approaches to best meet maritime specifications for this tracking mount in support of future testing of naval HEL programs. GSTM availability is expected in 1QFY21.

Broad Area Target System (BATS)
The Center is complementing its current HEL characterization test instrumentation suite with the BATS, which is a smart TB for directly detecting and characterizing a HEL beam at target distance. The BATS will provide the Center with a compact, standalone TB solution that can be integrated into operationally representative ground targets. The BATS sensor array spatially and temporally samples HEL beam profiles and is designed to be a reusable system that can withstand direct exposure to high power, continuous wave lasers. The BATS is a larger version of the "beam irradiance target system," which was the outcome of a PEO STRI Science and Technology project. BATS availability is expected in 2QFY21.

JSIS
JSIS provides the capability to collect MANPADS missile plume and hostile fire signatures, Time-Space-Position Information, and related data for ASE T&E and threat model development. JSIS's transportability allows it to be used both in the United States and abroad to reduce costs and expand the types of threat data available in the United States. The JSIS baseline was developed from FY13 through FY18 under sponsorship from the TRMC's CTEIP. JSIS 2.0, also sponsored by CTEIP, will provide a missile attitude determination capability. Implementation of the FOC began in FY19 and will be completed in FY23. The Center is also evaluating JSIS development to incorporate DEW T&E capabilities.

Intelligence agencies require high-fidelity threat data to produce/improve certified threat models (i.e., trajectory and signature), and threat models form the basis of the majority of ASE T&E. The Missile and Space Intelligence Center uses data collected by JSIS, including data collected during the FY20 CIRCM IOT&E Free Flight Missile event, to create threat models for use in modeling and simulation (M&S) of ASE. The Navy (PMA-272), Army (PMO ASE), and Air Force (LAIRCM System Program Office) have endorsed JSIS, and it will be an integral support element of each Program Office's aircraft self-protection capability development.

In FY18, JSIS reached its IOC. Among the added capabilities will be a full complement of signature data collection instrumentation to support current programs of record; a full complement of signature data collection instrumentation focused on emerging programs; additional instrumentation to support data collection for multiple, concurrent events; instrumentation to support static, live fire events; and full trajectory coverage for missile attitude related data collection along with supporting computer, network, and support trailers to field throughout the United States and outside the continental United States. The Preliminary Design Review was completed in May 2019 and Block I Critical Design Review was completed in October 2019.

Missile Simulator Emitters Upgrade

The Center is currently overseeing a TRMC-funded project to upgrade the emitters on JMITS/MSALTS. This upgrade will increase JMITS/MSALTS bandwidth and processing capabilities to meet the requirements of advanced MWS/DIRCM systems. IOC for the first upgraded simulator is expected during 1QFY21.

Threat Signature Generation

The Center continually generates plume signatures that are used as the input signatures for JMITS and MSALTS in open-air missile simulator testing of MWS/DIRCM systems. The Center has generated over 10,000 signatures for this purpose. Also, the Center provides signatures to various programs upon request for use in signature model analysis and test activities not involving the Center. The Center has been a key participant in multiple working groups, including the Test and Evaluation Threat Resource Activity (TETRA) IR Configuration Control Board and the IR Missile Model Management Group, which continually evaluate threat signature models with the goal of improving them and creating uniformity in model version use.

Towed Optical Plume Simulator (TOPS)

The TOPS system is currently an Air Force effort to investigate ways to improve the Towed Airborne Plume Simulator (TAPS) system by replacing the pyrophoric fuel source with solid-state optical emitter sources to simultaneously emit energy in two independently controlled IR bands (Red and Blue) and one UV band. The energy sources will be mounted in a pod towed behind an aircraft. In support of this effort, the Center provided short-range, ground-based data collection in past developmental phases. The project has now moved to its next phase, which consists of building a pod that can be towed behind an aircraft. Arnold Engineering Development Complex leads the project, and the Center participates and monitors the effort as a future technology improvement for the TAPS system.

Appendix

SECRETARY OF THE ARMY
WASHINGTON

1 8 DEC 2020

MEMORANDUM FOR Director, Operational Test and Evaluation, 1700 Defense Pentagon, Washington, DC 20301-1700

SUBJECT: Army Response to Fiscal Year 2020 Director, Operational Test and Evaluation Annual Report

1. Thank you for the opportunity to provide the Department of the Army response to the Director of Operational Test and Evaluation (DOT&E) Fiscal Year 2020 Annual Report.

2. I appreciate the thoroughness of the DOT&E report as well as the coordination between DOT&E and the Army. There has been significant progress in addressing many of the issues contained in the report. However, the Army provides the enclosed comments to the report.

3. We look forward to working with your office on implementing the recommendations to bring a better product to the Warfighter.

4. Thank you for your continued support of Army programs and our Soldiers.

5. My point of contact is Ms. Laura Pegher, Director, TE Coordinator, OASA(ALT), 571-256-9438 or laura.i.pegher.civ@mail.mil.

Encl

Ryan D. McCarthy

Enclosure

1. Pursuant to Section 815 of the Fiscal Year 2020 National Defense Authorization Act, I am providing comments to the Director of Operational Test and Evaluation (DOT&E) Fiscal Year 2020 Annual Report. The Army reviewed and coordinated this report for accuracy and security purposes prior to this final report. Based on the final review, the Army recognizes and thanks DOT&E for the reporting and recommendations on how to improve our programs in the future. In addition to what is documented within this report, the Army feels the need to expand upon a few specifics that the Congress may take particular interest. They are as follows:

a. The Aerosol Vapor Chemical Agent Detector (AVCAD), Pages 55-56. Due to COVID-19 supply chain disruptions, the two AVCAD vendors experienced supply chain delays and impacts to delivery schedules. The vendors are fixing the issues and in response the program office implemented additional engineering and manufacturing phase testing to address reliability issues and obtain full data sets for both vendors to support a Milestone C decision. Despite the schedule expansion, the program is on track to achieve original acquisition program baseline milestones.

b. The Family of Medium Tactical Vehicles (FMTV), Pages 61-63. An update on recent activities in November 2020, FMTV A2 began contractor funded shakedown testing at Aberdeen Test Center. Thirteen vehicles will complete a total of 19,500 miles in a staggered approach to prove out fixes made during the Corrective Action Period. Upon successful completion of shakedown miles the vehicle will re-enter USG Production Verification Testing in January 2021.

c. The Common Infrared Countermeasures (CIRCM), Pages 75-76. From March to July 2020, the U.S. Army Test and Evaluation Command (ATEC) conducted integration flight testing of the CIRCM system as integrated on the CH-47 Chinook platform. CIRCM operated as expected with no shortfalls during CH-47 Chinook integration flight testing. The Electromagnetic Interference (EMI) jitter, which was observed during UH-60 testing, was not observed during CH-47 testing. The Army designed and validated an UH-60 solution which provides CIRCM EMI hardened assets for fielding in 3QFY21.

d. The Infantry Squad Vehicle (ISV), Pages 83-84. As noted in the report the ISV has not demonstrated to date the capability to carry the required mission equipment, supplies, and water for a unit to sustain itself to cover a range of 300 miles within a 72-hour period. This will be demonstrated during the IOT&E in August 2021 at Fort Bragg, NC.

e. Army Test and Evaluation (T&E) Resources (Page 237). The Army agrees with DOT&E that ATEC performs a critical role by ensuring new warfighting systems are tested as they are intended to be employed by Soldiers. Army resourcing for developmental and operational test capabilities is integrated and is focused on seeking efficiencies and improved effectiveness of these precious capabilities. For the development of future multi domain operation testing and training technologies the Army is taking a comprehensive approach informed by both future threat capabilities and corresponding operating concepts. The Army recognizes the T&E opportunities as we integrate early Soldier feedback in material development. Demands are addressed through prioritization of T&E efforts for Army signature modernization efforts and optimizing investments made in T&E capabilities. Importantly, the Army is postured with adequate manning, processes, and partnerships to meet the T&E demands of Army modernization in order to ensure our Soldiers have the systems they need.

2. As noted in this report, the Army recognizes the need to develop and test our systems to counter Electronic Warfare and Navigation Warfare threats. Testing in a GPS-denied environment requires agile, enterprise test technologies; the Army is working with sister Services and Office of the Secretary of Defense (OSD) Test Resource Management Center (TRMC) to seek solutions to modernize these test capabilities.

THE SECRETARY OF THE NAVY
WASHINGTON DC 20350-1000

MEMORANDUM FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION

SUBJECT: Department of the Navy Comments on the FY2020 DOT&E Annual Report

Pursuant to your e-mail dated December 11, 2020, please find the Department of the Navy comments on the FY2020 DOT&E Annual Report. Although we have seen good collaboration and adjudication of several issues in the report, the following top level comments on some of our key programs are highlighted below:

- CVN 78 Gerald R. Ford-Class Nuclear Aircraft Carrier: The Navy concurs that efforts to improve system reliability should continue to ensure sortie generation rate requirements are met and the Navy is committed to doing so. The Navy is realizing the benefit of focused efforts over the last several years and, as an update to this DOT&E report, three more Independent Steaming Events (ISE 12, 13, & 14) have been completed with each demonstrating the Ford's ability to execute required sortie generation rates with an Air Wing embarked. The Ford has now recorded nearly 6,400 aircraft launches and recoveries, including over 5,600 launches and recoveries since January 2020, demonstrating the growing proficiency of the crew to operate and maintain shipboard systems and conduct relevant operations in an operational environment while underway a total of 232 days.

- Amphibious Combat Vehicle (ACV) Family of Vehicles: The report notes egress challenges for the ACV, but in test the vehicle exceeded the threshold emergency egress requirement and is approaching the objective requirement to debark the crew and embarked Marines while afloat. Of note, the demonstrated ACV emergency egress is a significant improvement over the legacy predecessor vehicle, the Amphibious Assault Vehicle.

- F-35 Joint Strike Fighter: The JPO is assessing the lessons learned from C2D2 early execution and commissioned an independent review team to identify improvements required in infrastructure, processes, and tools across capability planning, development, and test to deliver capabilities more efficiently and effectively to the fleet.

Thank you for this opportunity to comment on the FY2020 DOT&E Annual Report.

Kenneth J. Braithwaite

Copy to:
ASN(RD&A), PCD/PMD ASN(RD&A)
DASN(RDT&E)

UNDER SECRETARY OF THE AIR FORCE
WASHINGTON

JAN 0 4 2021

MEMORANDUM FOR THE DIRECTOR, OPERATIONAL TEST AND EVALUATION

SUBJECT: Department of the Air Force Response to Fiscal Year 2020 Director, Operational Test and Evaluation (DOT&E) Annual Report

I appreciate the opportunity to review this 2020 report. In general, this annual report accurately reflects the status of oversight programs in the Department of the Air Force. Additionally, it faithfully identifies the challenges and opportunities of resourcing the Department of Defense test enterprise as a critical enabler for the rapid, all-domain acquisition required by tomorrow's Airmen and Space Professionals to meet the peer threat. The Department of the Air Force looks forward to continued engagement with DOT&E in the future.

Shon J. Manasco
Acting

cc:
AF/CV
AF/TE

Index

Index

V

www.dote.osd.mil