SECOND ADDENDUM TO UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

F-22A, T/N 06-4125

525TH FIGHTER SQUADRON
3RD WING
JOINT BASE ELMENDORF-RICHARDSON, ALASKA

LOCATION: JOINT BASE ELMENDORF-RICHARDSON, ALASKA
DATE OF ACCIDENT: 16 NOVEMBER 2010
BOARD PRESIDENT: BRIG GEN JAMES S. BROWNE
CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

F-22A, T/N 06-4125
JOINT BASE ELMENDORF-RICHARDSON, ALASKA
16 NOVEMBER 2010

On 16 November 2010, at approximately 19:43:27 hours local time (L), an F-22A, tail number 06-4125, assigned to the 525th Fighter Squadron, 3rd Wing, Joint Base Elmendorf-Richardson (JBER), Alaska, impacted the ground during controlled flight approximately 120 nautical miles (NM) northeast of JBER. The mishap pilot (MP) did not attempt ejection and was fatally injured upon impact. The mishap aircraft (MA) was destroyed. There was no damage to private property. A damage cost of $147,672,000.00 includes the total destruction of the MA along with its internal stores.

The mishap occurred on a 3-ship night opposed surface attack tactics (SAT) training mission. Opposed SAT missions typically consist of F-22As fighting their way into a target area protected by enemy forces and dropping Joint Direct Attack Munitions (JDAM) on specified targets. During the return-to-base portion of the mission while the MP was attempting to rejoin with his flight lead, the MA experienced an engine bleed air leak malfunction at 19:42:18L. At approximately 19:42:37L, airflow to MP's oxygen mask stopped. At 19:42:53L, the MP entered a 240-degree roll through inverted flight, and the nose down (ND) pitch attitude increased. At approximately 19:43:24L, the MP initiated a dive recovery. Three seconds later, the MA impacted the ground in a left bank at approximately 48 degrees ND at a speed greater than 1.1 Mach (M).

The Convening Authority approved the Accident Investigation Board Report on 14 November 2011, and the [First] Addendum on 17 June 2012. On or about 17 October 2012, General Herbert J. Carlisle (PACAF/CC), appointed an F-22 Life Support Systems Task Force to conduct specific analysis concerning the AIB report. On 18 December 2012, General Carlisle reconvened the AIB and directed the Board President to evaluate the information contained within the Task Force Report (as well as any other matters the Board President deemed relevant) and consider whether it impacted, in any way, the previous narrative and conclusions contained in the AIB Report. The Board President was assisted by the original AIB Members.

The Board President found, by clear and convincing evidence, the cause of the mishap was the MP's failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan, and unrecognized spatial disorientation. Additionally, the Board President found, by a preponderance of the evidence, organizational training issues, personal equipment interference, controls and switches, and inadvertent operation were factors that substantially contributed to the mishap.

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

SUMMARY OF FACTS AND STATEMENT OF OPINION
F-22A, T/N 06-4125
16 NOVEMBER 2010

TABLE OF CONTENTS

COMMONLY USED ACRONYMS AND ABBREVIATIONS

3MG	3rd Maintenance Group
3WG	3rd Wing
AF	Air Force
AFB	Air Force Base
AFE	Aircrew Flight Equipment
AFI	Air Force Instruction
AFIP	Air Force Institute of Pathology
AFPAM	Air Force Pamphlet
AGL	Above Ground Level
AIB	Aircraft Investigation Board
AK	Alaska
ALERTS	Aircrew Life Support Equipment Reporting and Tracking System
ALSOMS	Aircrew Life Support Management System
AMP	Aerospace Medical Primary Course
ANC	Anchorage
AOC	Air and Space Operations Center
ATAGS	Advanced Tactical Anti-G System
ATC	Air Traffic Control
ATIS	Automated Terminal Information System
B-Man	Crew Chief w/Fire Extinguisher
BFM	Basic Fighter Maneuvers
BRAG	Breathing Regulator/Anti-G
CAC	Common Access Card
CAP	Combat Air Patrol
Capt	Captain
CAUT	Caution
CIP	Core Integrated Processor
Col	Colonel
CRUZR	A Navigational Point
CSMU	Crash Survivable Memory Unit
CTK	C Toolkit
DO	Director of Operations
DoD	Department of Defense
DTC	Data Transfer Cartridge
ECS	Environmental Control System
EO	Electro-Optics
EOR	End of Runway
EOS	Emergency Oxygen System
EPS	Emergency Power System
FAA	Federal Aviation Administration
FL	Flight Lead
FLCS	Flight Control System
FLUG	Flight Lead Upgrade
FOD	Foreign Object Debris/Damage
fpm	Feet Per Minute
fps	Feet Per Second
FPS	Fire Protection System
FRC	Fault Reporting Codes
FS	Fighter Squadron
ft	Feet
G	Gravitational Force
GTC	Government Travel Card
GX	G-Force Exercise
HUD	Head-up Display
IAW	In Accordance With
ICAWS	Integrated Caution, Advisory and Warning System
IFDL	Intra-Flight Data Link
IMIS	Integrated Maintenance Information System
IP	Instructor Pilot
IPR	Instructor Pilot of Record
IR	Infra Red
IVSC	Integrated Vehicle Subsystem Controller
JBER	Joint Base Elmendorf-Richardson
JDAM	Joint Direct Attack Munitions
K	Thousand
KCAS	Knots Calibrated Airspeed
KTAS	Knots True Airspeed
kts	Knots (Nautical Miles Per Hour)
L	Local Time
LEFL	Lead Element Flight Lead
LEW	Lead Element Wingman
LM-Aero	Lockheed Martin Aeronautics Company
LOS	Law Office Superintendent
LP	Life Preserver
Lt Col	Lieutenant Colonel
LWD	Left Wing Down
M	Mach
MA	Mishap Aircraft
Maj	Major

MAJCOM	Major Command
MCC	Mishap Crew Chief
MFL	Mishap Flight Lead
MOA	Military Operating Area
MP	Mishap Pilot
MS	Mishap Sortie
MSF	Mishap Supervisor of Flying
MSL	Mean Sea Level
MW	Mishap Wingman
NCO	Non-Commissioned Officer
ND	Nose Down
NM	Nautical Miles
NOTAMS	Notices to Airmen
NORDO	Term indicating "no radios"
NVGs	Night Vision Goggles
OBIGGS	On-board Inert Gas Generating System
OBOGS	On-board Oxygen Generating System
OCA	Offensive Counter Air
ODS	Operational Debrief System
OG	Operations Group
OPR	Officer Performance Report
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSS	Operation Support Squadron
P&W	Pratt and Whitney
PA	Public Affairs
PAO	Polyalphaolefin
PACAF	Pacific Air Forces
PHA	Physical Health Assessment
PMP	Packaged Maintenance Plan
PR	Pre Flight
PSI	Pounds Per Square Inch
PW	Pilot Witness
QA	Quality Assurance
RESCAP	Rescue Combat Air Patrol
RTB	Return-To-Base
RWD	Right Wing Down
SA	Situational Awareness
SAR	Search and Rescue
SAT	Surface Attack Tactics
SEPT	Supervised Emergency Procedure Training
SES	Stored Energy System
SIB	Safety Investigation Board
SIB DOC	SIB Flight Surgeon/Medical Advisor
SIB HF	SIB Human Factors Advisor
SIB IO	SIB Investigating Officer
SIB LSO	SIB Life Support Officer
SIB MM	SIB Maintenance Member
SIB SC	SIB Safety Center Representative
SII	Special Interest Item
SOF	Supervisor of Flying
TCAS	Terrain Collision Avoidance System
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
T/N	Tail Number
TO	Technical Order
TOD	Technical Order Data
Top 3	Operations Supervisor
TUC	Time of Useful Consciousness
VDC	Video Data Cartridge
VVI	Vertical Velocity Indication
WIC	Weapons Instructor Course

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and Witness Testimony (Tab V).

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 19 November 2010, General Gary L. North, then-Commander, Pacific Air Forces (PACAF/CC), appointed Brigadier General James S. Browne, in accordance with (IAW) Air Force Instruction (AFI) 51-503 to conduct an aircraft accident investigation of a mishap that occurred on 16 November 2010 involving an F-22A Raptor aircraft, tail number (T/N) 06-4125, near Joint Base Elmendorf-Richardson (JBER), Alaska (AK). The investigation was conducted at JBER, from 4 January 2011 through 14 January 2011, 30 May 2011 through 13 June 2011, and 11 July 2011 through 21 July 2011. The Accident Investigation Board (AIB) advisors were: a pilot advisor, a maintenance officer advisor, original legal advisor, a medical advisor, a human factors advisor, a maintenance enlisted advisor, and a recorder. (Tabs Y-3 through Y-8, Second Addendum Tabs B-18 through B-20) On 10 February 2011, General North, appointed a new legal advisor as a substitute for the original legal advisor. (Tabs Y-9 through Y-10) General North approved the original AIB report on 14 November 2011. (Second Addendum Tab B-19)

On 4 April 2012, General North reopened the AIB. ([First] Addendum Tab A-3) Brigadier General Browne conducted the investigation at Barksdale Air Force Base, Louisiana, from 5 April 2012 to 28 April 2012. He was assisted by members of the original AIB, along with a [second] substituted legal advisor. General North approved the [First] Addendum on 17 June 2012.

On 18 December 2012, General Herbert J. Carlisle (now PACAF/CC) reconvened the AIB. (Second Addendum Tab A-3) Brigadier General Browne conducted the investigation at Barksdale Air Force Base, Louisiana, from 2 January 2013 to 5 January 2013; Langley Air Force Base, Virginia, from 22 January 2013 to 25 January 2013; and returned to Barksdale Air Force Base, Louisiana, and prepared the report from 25 January 2013 to 7 March 2013. He was assisted by the members of the original AIB. (Second Addendum Tabs A-3, B-18 through B-20)

b. Purpose

This is a legal investigation convened to inquire into the facts surrounding the aircraft or aerospace accident, to prepare a publicly-releasable report, and to gather and preserve all available evidence for use in litigation, claims, disciplinary actions, administrative proceedings, and for other purposes.

[FIRST] ADDENDUM PURPOSE: On 4 April 2012, the investigation was reopened to allow the Board President to consider evidence recently discovered by the AIB maintenance enlisted advisor. The evidence was a data file with unconverted parametric data, which could point to new information on a potential mechanical failure point. ([First] Addendum Tabs A-3, B-3 through B-9) The aircraft's data file did not provide any new insight into the mishap. ([First] Addendum B-3)

SECOND ADDENDUM PURPOSE: On or about 17 October 2012, General Herbert J. Carlisle (PACAF/CC), appointed an F-22 Life Support Systems Task Force to conduct specific analysis concerning the AIB report. On 18 December 2012, General Carlisle reconvened the AIB and directed the Board President to evaluate the information contained within the Task Force Report (as well as any other matters the Board President deemed relevant) and consider whether it impacted, in any way, the previous narrative and conclusions contained in the AIB Report. The Board President was assisted by the original AIB Members. (Second Addendum Tab A-3)

NOTES: Tabs A through EE-3 of the Original AIB Report contain minor corrections and additional redactions to prevent inadvertent release of personal identifying information and address concerns as to whether certain materials are authorized for public release, particularly the Technical Reports contained in Tab J. No page numbers were changed, and no additional documents were added.

A bar (|) in the left-hand margin indicates revision of information from the original report. For ease of reading, administrative and grammatical corrections were also incorporated, but not indicated by a bar.

2. ACCIDENT SUMMARY

At 18:17 hours local time (L), 16 November 2010, the mishap pilot (MP) flying an F-22A, T/N 06-4125 (the mishap aircraft (MA)), departed JBER as number 3 of a 3-ship formation for an opposed surface attack tactics (SAT) training mission. Opposed SAT missions typically consist of F-22As fighting their way into a target area protected by enemy forces and dropping Joint Direct Attack Munitions (JDAM) on specified targets. The weather in the area was clear with unlimited visibility and 74% moon illumination over snow covered terrain. The tactical mission portion of the flight was completed uneventfully. At 19:39:57L, during the return-to-base (RTB) portion of the flight, data from the mishap flight lead's (MFL) intra-flight data link (IFDL) showed the MP in front of the MFL bearing 131 degrees at 13 nautical miles (NM), heading 183 degrees, 1,039 knots true airspeed (KTAS) at 38,400 feet (ft) above mean sea level (MSL). At some time after that, the MFL directed the MP to rejoin. According to the recovered crash survivable memory unit (CSMU), at 19:40:44L the MP entered a climbing right turn to commence the rejoin. At 19:42:18L, a C BLEED HOT caution integrated caution, advisory, and warning (ICAW) asserted (a visual and audible cue to the MP). At approximately 19:42:37L, airflow to MP's oxygen mask stopped. At 19:42:53L, the MP entered a 240-degree roll through inverted flight, and the nose down (ND) pitch attitude increased. At 19:43:24L, the MP initiated a dive recovery. Approximately three seconds later, the aircraft impacted the ground 48 degrees ND at a speed greater than 1.1 Mach (M) and was destroyed. A damage cost of $147,672,000.00 includes the destruction of the MA along with its internal stores. The MP did not eject and was fatally injured.

3. BACKGROUND

The MA was assigned to and operated by the 525th Fighter Squadron (525FS), 3rd Wing (3WG), Eleventh Air Force (11AF), at Joint Base Elmendorf-Richardson (JBER), which are subordinate units to Pacific Air Forces (PACAF).

a. Unit Information

(1) Pacific Air Forces, Joint Base Pearl Harbor-Hickam, Hawaii

PACAF's primary mission is to provide U.S. Pacific Command integrated expeditionary Air Force capabilities to defend the homeland, promote stability, dissuade/deter aggression, and swiftly defeat enemies. The command's vision is to bring the full power of America's Air Force and the skill of its Airmen to promote peace and stability in the Asia-Pacific region. PACAF's area of responsibility extends from the west coast of the United States to the east coast of Africa and from the Arctic to the Antarctic, covering more than 100 million square miles. The area is home to 50 percent of the world's population in 36 nations and over one-third of the global economic output. (Tab DD-3)

(2) Eleventh Air Force, Joint Base Elmendorf-Richardson, Alaska

The Eleventh Air Force (11AF) plans, conducts, controls and coordinates air operations IAW the tasks assigned by the PACAF commander, and is the force provider for Alaskan Command, the Alaskan Aerospace Defense Command Region, and other unified commands. Its units provide a network of critical air surveillance and command, control and communications functions necessary to perform tactical warning and attack assessment in defense of Alaska. (Tab DD-6)

(3) 3rd Wing, Joint Base Elmendorf-Richardson, Alaska

The 3rd Wing trains and equips an Air Expeditionary Force lead wing comprised of more than 2,400 Airmen and F 22A, E-3B, C-17, C-12, and C-130 aircraft. It provides trained and equipped tactical air superiority forces, all-weather strike assets, command and control platforms and tactical airlift resources to project global power and global reach. (Tab DD-8)

(4) 525th Fighter Squadron

525FS is a combat-ready fighter squadron prepared for rapid worldwide deployment of F-22A Raptor aircraft to accomplish precision engagement of surface targets using a wide variety of conventional air-to-surface munitions. 525FS trains in the fighter missions of strategic attack, interdiction, offensive counterair (air-to-surface), suppression of enemy air defenses, as well as offensive and defensive counterair (air-to-air). (Tab DD-9)

525FS originally activated as the 309th Bombardment Squadron (Light) on 10 February 1942. In 1943, the 309th Bombardment Squadron was redesignated as the 525th Fighter-Bomber Squadron; then redisignated as the 525FS in 1944. The 525th Tactical Fighter Squadron inactivated on 1 April 1992. After 15 years of inactivation, PACAF redesignated and activated the 525FS at Elmendorf Air Force Base (which was renamed Joint Base Elmendorf-Richardson), on 29 October 2007. (Tabs DD-9, DD-12 through DD-15)

b. F-22A Raptor

The F-22A Raptor is a single seat, multi-role fighter aircraft. Its combination of stealth, supercruise, maneuverability, and integrated avionics, coupled with improved supportability, represents an exponential leap in warfighting capabilities. The Raptor performs both air-to-air and air-to-ground missions allowing it to project air dominance and defeat threats attempting to deny access to our nation's Air Force, Army, Navy and Marine Corps. (Tabs DD-16 through DD-17)

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie (MS) was scheduled and briefed as a night opposed SAT mission with aerial refueling. (Tabs J-4, R-4 through R-5, R-162) The mission involved six F-22As with callsigns Jake 01 through 03 (Jake flight) and Rocky 01 through 03 (Rocky flight). (Tab K-5) These six were joined by four F-16s from Eielson AFB, AK, callsigns Mig 01 through Mig 04. (Tabs R-57, R-161) The pilot of Rocky 01 was the MFL, and the pilot of Rocky 03 was the MP. Originally, the F-22As were to proceed to a tanker, conduct aerial refueling, fight an opposed SAT mission, aerial refuel once more, and then conduct an additional unopposed SAT mission. Due to a delay in the takeoff time for high winds at JBER, the F-22As did not refuel prior to their first opposed SAT mission. (Tabs J-4, K-5, K-12, R-4 through R-5, R-60 through R-61, R-158)

Jake and Rocky flights took off 10 minutes apart and operated as two separate flights of friendly forces (Blue Air) fighting Mig flight acting as enemy forces (Red Air). (Tabs K-18, R-4, R-60, R-61) The purpose of this mission was a night flight lead (FL) upgrade mission for Jake 01 with

Jake 03 (525FS Commander) as his qualified instructor pilot (IP) and a night continuity training sortie for Rocky 01 through 03. (Tabs K-10, R-4 through R-5, R-57, R-60, R-61)

The mishap mission was flown in Dice and Paxson Airspace scheduled by 3WG for these training purposes. Dice and Paxson are over land, designated military operating areas (MOAs) north of JBER. 525FS Director of Operations properly authorized the mission. (Tabs K-5, K-9, K-22)

b. Planning

Jake 01 planned and briefed the mission as a SAT FL upgrade sortie IAW 3WG Administrative Standards, F-22A In-Flight Guide Supplement, and applicable Tactics, Techniques and Procedures. All Jake flight and Rocky flight members attended the entire brief at 15:15L. The flight briefing covered all administrative flight information, weather, Notices to Airmen (NOTAMS), training rules, Special Interest Items, tanker operations, deconfliction between the two F-22A flights, and all items necessary to safely conduct the planned SAT training mission. Additionally, extra emphasis was placed on night operations. (Tabs K-10, K-13 through K-16, R-13, R-17, R-53)

c. Preflight

In accordance with 3WG Administrative Standards, all flight members were required to focus their night vision goggles (NVGs) prior to the brief in order to prepare for the night mission. (Tabs V-2.4, V-10.3 through V-10.4) All six pilots arrived at the operations desk for a final update briefing on weather, NOTAMS and other pertinent safety-of-flight information prior to going to their aircraft. (Tab R-84) The pilots were delayed approximately 20 minutes due to crosswinds at JBER. (Tab R-4) After the winds were within limits, the operations supervisor (Top 3) gave the pilots their final update briefing. (Tabs R-84 through R-85) This was the first mission of the season where Category III (CAT III) cold weather gear was required based on low temperatures in the airspace. (Tabs H-50 through H-55, R-84 through R-85, Second Addendum Tab B-10) Additionally, the pilots used Operational Risk Management (ORM) to evaluate mission risk. ORM is a decision-making process to systematically evaluate possible courses of action, identify risks and benefits, and determine the best course of action for any given situation. There are three categories: low, medium, and high. The ORM category for the mission was in the high range based on night operations, the changes to the mission due to a delayed takeoff for winds, and the fact that the MS was the MP's second event of the day. The MP's first event of the day was acting as the supervisor of flying (SOF). (Tabs K-7, K-17, R-84) The Top 3 and the squadron commander made the decision to continue with the mission based on clear weather, diminishing winds, and minimal changes to the mission. (Tab R-84)

The pilots went to life support, donned the appropriate winter clothing and flight gear, and proceeded to their aircraft. (Tabs R-20, R-37, R-73) The MP accomplished pre-flight inspections IAW TO 1F-22A-1 and 1F-22A-34 checklists. Ground and taxi operations were uneventful. (Tabs R-34, R-63, R-85, R-130 through R-133)

d. Summary of Accident

Jake flight took off at 18:05L; Rocky flight departed 10 minutes later. (Tab K-5) Departure and entrance into the Dice MOA was uneventful, and the weather in the airspace was clear with high moon illumination. (Tabs F-3, R-34, R-158) Jake flight arrived at the designated airspace first. As Rocky flight entered the airspace, Jake flight completed their first mission and proceeded to the KC-135 air refueling tanker as briefed. After refueling, Jake flight returned to the airspace, executed their second SAT mission opposed, because Mig flight had additional fuel available, and returned to JBER. (Tabs R-5, R-46)

Rocky flight's first opposed SAT mission against Mig flight was uneventful. Rocky 02 reached a previously briefed fuel quantity prior to the MFL and MP, and proceeded to the tanker as a single aircraft, and refueled. The MFL and MP followed Rocky 02 to the tanker to refuel. While on the tanker, Rocky 02 was troubleshooting minor, non-safety-of-flight related avionics issues. The MFL directed Rocky 02 to return to Dice MOA to continue troubleshooting. (Tabs R-4 through R-5, R-34, R-58, R-158) Once the issues were resolved, the MFL directed Rocky 02 to fly an unopposed SAT mission as a single aircraft and RTB. (Tab R-5)

After receiving fuel, the MFL and MP executed a second unopposed SAT mission, in accordance with the brief. Upon completion of tactical maneuvering, the flight proceeded towards the airspace exit point to RTB. (Tabs R-5 through R-6)

At 19:39:57L, the last recorded data from the MFL IFDL showed the MA 13 NM in front of the MFL bearing 131 degrees, heading 183 degrees, 1.6 M at 38,400 ft MSL. (Tab J-4)

The MFL directed the MP to rejoin to a 2 NM trail formation. The MP acknowledged the MFL's directive to rejoin and made no further communications. (Tab R-158) The MP began a climbing right-hand turn to rejoin. The MA climbed to a maximum altitude of 51,720 ft MSL, crossed the MFL's projected flight path and then began a descent to the north. (Tabs R-30, EE-3)

At 19:42:18L, the MA was at 50,870 ft MSL, 315 knots calibrated airspeed (KCAS), 1.23 M, with an attitude of 1-degree nose up, 69 degrees right wing down (RWD), heading 323 degrees, 1.5-Gs, and with a vertical velocity indication (VVI) of -1,700 ft per minute (fpm). (Tab EE-3 and Figure 1) At this time, the fire protection system (FPS) detected a bleed air leak in the center bleed air ducting from both engines. (Tabs J-12, J-42) In response to the FPS, the Integrated Vehicle Subsystem Controller (IVSC) asserted the C BLEED HOT caution ICAW while it requested the Environment Control System (ECS) to isolate the center bleed system. "CAUT" was displayed in the head-up display (HUD) advising the MP of the caution ICAW. (Tab J-12 and Figure 1)

Figure 1 19:42:18L -- MA parameters at assertion of C BLEED HOT caution ICAW. (Tab EE-3) (See Tab Z-10 for a diagram explaining the symbology in the Figures.)

According to TO 1F-22A-1, a caution ICAW message warns a pilot of an "[a]ircraft operation that could result in damage to aircraft. Corrective procedures may be required, but not immediately." (Second Addendum Tab D-4) When the C BLEED HOT caution ICAW asserted, the following functions were automatically shutdown to protect against a bleed air induced aircraft fire:

1) ECS
2) Air Cycle System (ACS) forced air cooling
3) On-board oxygen generating system (OBOGS)
4) On-board inert gas generating system (OBIGGS)
5) Cabin pressure

Despite the loss of these functions, the flight control system and both engines were operating normally and responding to pilot inputs. (Tabs J-21, J-36, O-13, BB-17, BB-30, EE-3, [First] Addendum B-3)

The C BLEED HOT caution ICAW cleared at 19:42:21L after the IVSC commanded the bleed air ducts to the closed position and stopped the flow of bleed air to the ECS. At 19:42:23L, the OBOGS FAIL caution ICAW asserted when the OBOGS output pressure dropped below 10 pounds per square inch (psi). (Tabs J-12, O-13, and Figure 2) The CSMU data showed partial pressure to the MP's oxygen mask stopped shortly after 19:42:37L. (Tabs J-13 and J-43)

Figure 2 19:42:23L -- MA parameters at assertion of OBOGS FAIL caution ICAW. (Tabs EE-3, Z-10)

From the assertion of the OBOGS FAIL caution ICAW until 19:42:45L, the MP retarded the throttles to IDLE power and continued a controlled, descending right-hand turn. (Tabs BB-28, BB-29, EE-3 and Figure 3) At 19:42:45L, the MA was at 41,460 ft MSL, 390 KCAS, 1.29 M, 30 degrees ND, 44 degrees RWD, 1.7-Gs, and with a VVI of -33,700 fpm. (Tab EE-3 and Figure 3)

Figure 3 19:42:45L -- MP deliberately flew to a controlled attitude of 30 degrees ND and 44 degrees RWD. (Tabs EE-3, Z-10)

For eight seconds, from 19:42:45L until 19:42:53L, the MP made no inputs to the stick, pedals, or throttles, and the MA maintained a relatively stable bank angle and attitude. At 19:42:53L, the MA was at 37,110 ft MSL, 470 KCAS, 1.35M, 30 degrees ND, 46 degrees RWD, 0.8-G, with a VVI of -37,700 fpm. (Tab EE-3 and Figure 4)

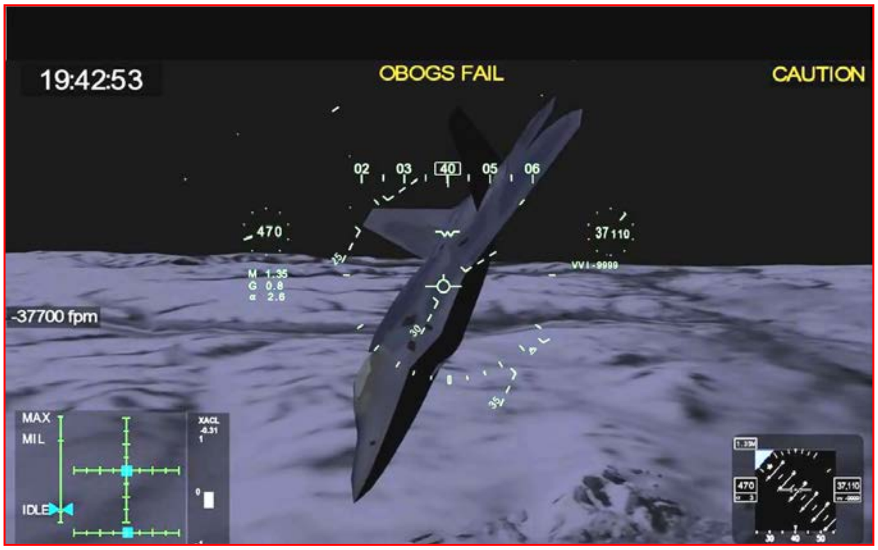

Figure 4 19:42:53L -- MA parameters after 8 seconds of zero MP inputs to stick, pedals, or throttles. (Tabs EE-3, Z-10)

At 19:42:53L, the MP input a combination of right forward stick and right pedal which initiated a 240-degree descending right roll at greater than 45 degrees per second. (Tab EE-3 and Figure 4, above)

By 19:43:08L, the MA had rolled through inverted flight, experienced less than 1-G of gravitational force, reversed turn direction from RWD to left wing down (LWD), increased ND attitude, and significantly increased the descent rate. The parameters at this time were 24,070 ft MSL, 627 KCAS, 1.39 M, 44 degrees ND, 81 degrees LWD, 0.8-G, with a VVI of -57,800 fpm. (Tab EE-3 and Figure 5)

Figure 5 19:43:08L -- MA parameters after the 240-degree roll. (Tabs EE-3, Z-10)

After 19:43:08L, there were no stick inputs and only very minor pedal inputs for the next 15 seconds. During this time, the descent rate of the MA increased to greater than 1,000 feet per second (fps), and at 19:43:13L, as the MA passed approximately 19,000 ft MSL, a CABIN PRESSURE caution ICAW asserted based on cockpit pressurization exceeding its normal schedule. (Tabs J-13, EE-3, and Figure 6)

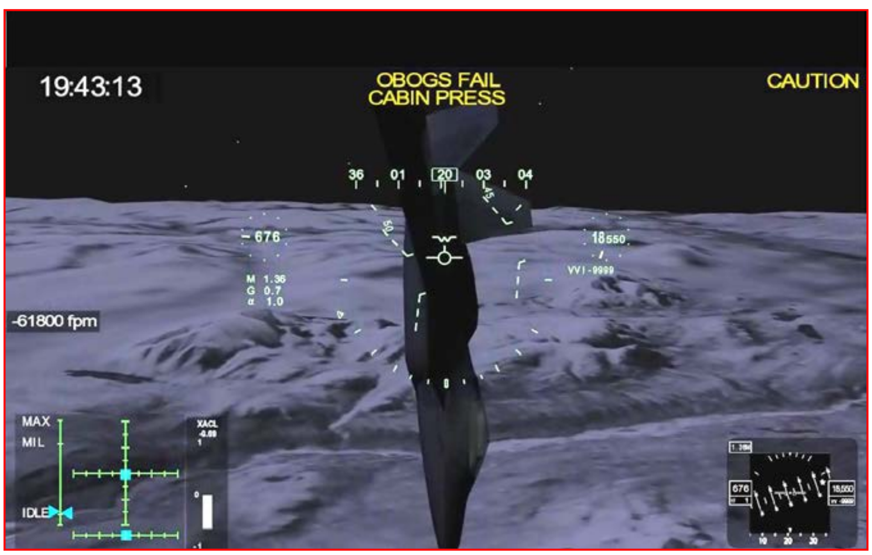

Figure 6 19:43:13L -- MA parameters at assertion of CABIN PRESS caution ICAW. (Tabs EE-3, Z-10)

At 19:43:18L, passing 12,400 ft MSL, an AIR COOLING caution ICAW asserted. This AIR COOLING caution ICAW asserted 60 seconds after the C BLEED HOT caution ICAW asserted at 19:42:18L, which meant the MA was not receiving an adequate cooling air source to its avionics. (Tabs J-13, J-28, EE-3, and Figure 7)

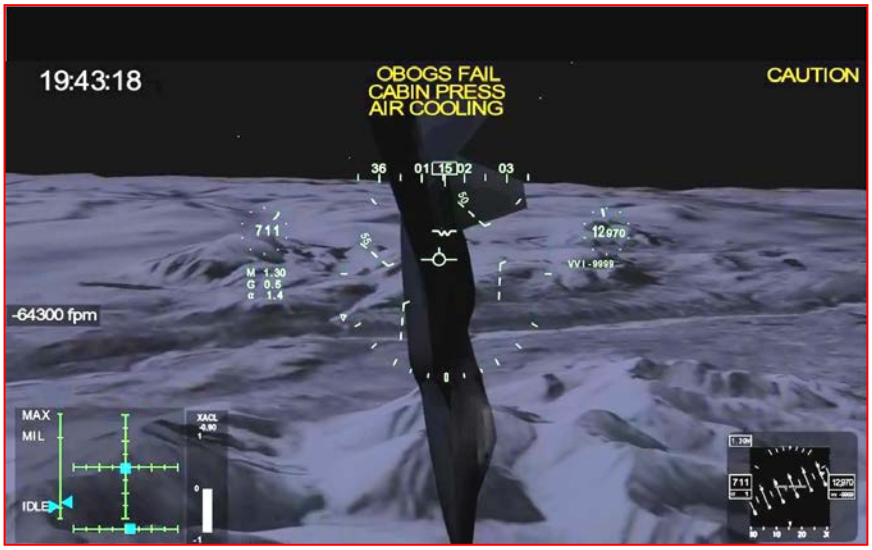

Figure 7 19:43:18L -- MA parameters at assertion of AIR COOLING caution ICAW. (Tabs EE-3, Z-10)

At 19:43:24L the MP performed a dive recovery at 5,470 ft MSL by pulling aft on the stick, producing a 7.4-G pull up maneuver. By this time, the MA had transitioned below the minimum safe recovery altitude. (Tabs J-19, EE-3, and Figure 8) The MA impacted the ground three seconds later, inflicting fatal injuries to the MP and destroying the MA. (Tabs D-3, J-4, J-13, X-3, EE-3)

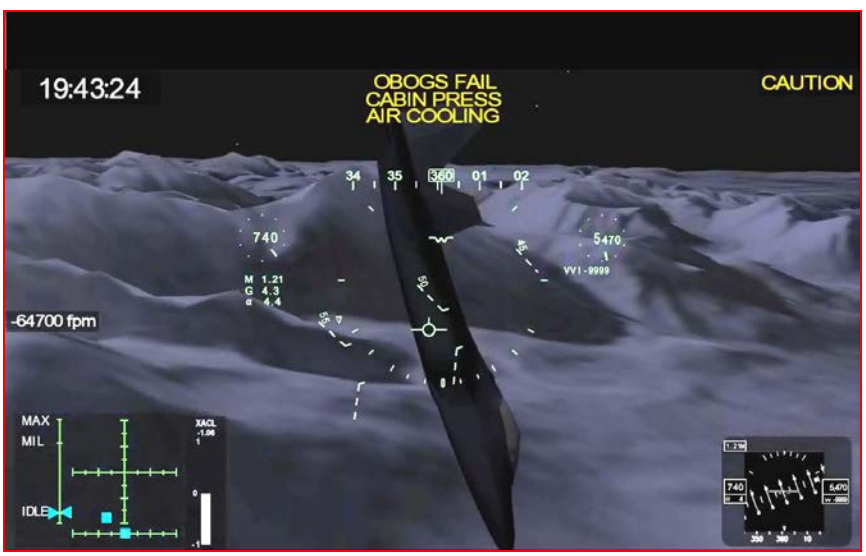

Figure 8 19:43:24L -- MP initiates full aft stick pull to start dive recovery at 5,470 ft MSL. (Tabs EE-3, Z-10)

e. Impact

At 19:43:27L, the MA impacted the ground at 735 KCAS, 1.17 M, 48 degrees ND, 48 degrees LWD, 7.4-Gs, with a VVI of -57,900 fpm. The impact site is approximately 120 NM north of JBER, AK, in the Talkeetna Mountain range. The site is approximately 3,100 ft MSL near the edge of a south-west to north-east running valley. The impact crater is located at the valley floor where it begins to slope upwards towards the southeast. The valley floor is approximately one-half mile wide at this point and has a stream running through it approximately 60 yards west of the impact point. (Tabs J-4 through J-6, H-5, EE-3, and Figure 9)

The debris field consisted of small aircraft and engine pieces extending approximately one-quarter mile from the crater. The upslope wall of the crater and aircraft impact angle appear to have focused the debris pattern in a 60- to 80-degree wide arc from west to north. (Tabs J-4 through J-6, and Figures 10 and 11)

Figure 9 -- Impact Crater 17 Nov 2010. (Tab S-7)

Figure 10 -- Impact Site. 17 Nov 2010. (Tab S-7)

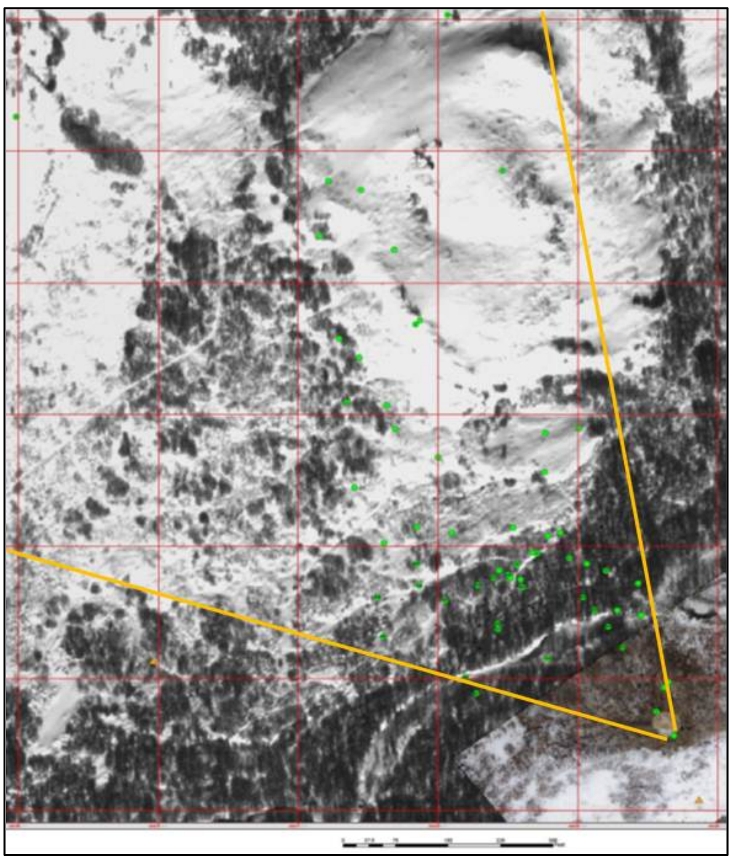

Figure 11 -- Aircraft Parts Scatter Diagram. Parts represented by green dots. (Tab S-4)

f. Egress and Aircrew Flight Equipment (AFE)

All life support equipment onboard the MA had current inspection dates and were deemed serviceable by 3rd Operational Support Squadron (3OSS) AFE members. (Tabs H-17 through H-23) The MP had two repairs performed on his advanced tactical anti-G system (ATAGS) on both the preceding day and the day of the mishap. (Tabs H-12 through H-13) All repairs, modifications, testing, and fittings were performed by qualified AFE members IAW all applicable technical orders (TO). (Tabs H-12, R-117 through R-121)

Based on analysis of the escape system and life support equipment located in the debris field, an ejection did not occur, and therefore, evidence suggests that the MP had no opportunity to use survival gear or life support equipment after impact. (Tabs H-5 through H-9)

Analysis was conducted to determine if the MP's oxygen mask was secured at the time of ground impact. A portion of the MP's helmet that included the right mask bayonet and right helmet receiver were submitted to the Air Force Research Laboratory Materials Integrity Branch (AFRL/RXSA) for evaluation. Due to the severe break-up of the MA, the left side bayonet and the MP's oxygen mask were not available for analysis. (Tabs J-68, J-71 through J-77, J-98 through J-105) The AIB used the report findings and the following indirect evidence to determine that the MP's oxygen mask was up and secured during the mishap sequence of events:

(1) The MP was at high altitude requiring supplemental oxygen when the MA bleed air malfunction occurred. As such, the MP would have had the mask secured to ensure proper oxygen concentration flow. (Tabs J-12, EE-3; Second Addendum Tab B-4, and Figure 12; see also AFI 11-202, Volume 3, *General Flight Rules, Flying Operations*, 5 April 2006, Paragraph 6.4 and Table 6.2);

Figure 12 -- F-22A Pilot wearing helmet with mask up and secured. (Second Addendum Tab C-4)

(2) The mask would need to be up and secured in order for the MP to receive the full benefit of the oxygen from the EOS. (Second Addendum Tab B-4);

(3) The MP could have lowered the left side of the mask, however, it is not common to do so. (Second Addendum Tab B-4) There are communication and helmet air bladder connections on the left side of the helmet, which would allow for only partial lowering of the oxygen mask. (Second Addendum Tab B-4 and Figures 13 and 14) In addition, if the MP disconnected the left bayonet, EOS oxygen would leak excessively out of the MP's mask once activated. (Second Addendum Tab B-4)

Figure 13 -- F-22A Pilot wearing helmet with left mask bayonet disconnected. (Second Addendum Tab C-4)

Figure 14 -- F-22A Pilot wearing helmet with right mask bayonet disconnected. (Second Addendum Tab C-6)

Therefore, based on a totality of the direct and indirect evidence available, the AIB determined the MP's oxygen mask was up and secured throughout the duration of the mishap sequence of events.

g. Search and Rescue (SAR)

At 20:10L on 16 November 2010, 11AF Rescue Coordination Center received notification of an overdue aircraft. The MFL, Alert F-22As, and KC-135 all performed initial on-scene and search and rescue efforts. Alaska Air National Guard HH-60s and HC-130s located the crash site the following morning. SAR team analysis of the crash site determined that the MP did not eject from the aircraft. Significant snowfall with sub-freezing temperatures began the following week, covering the aircraft wreckage and making location and identification of aircraft wreckage more difficult. (Tabs J-5, R-98 through R-99, AA-3 through AA-4)

h. Recovery of Remains

Recovery operations were conducted by the Joint Base Elmendorf-Richardson Emergency Operations Center. Remains were recovered during the initial recovery beginning 17 November 2010 and additionally when the recovery team reconvened at the site in May 2011. The remains were transferred to the Air Force Institute of Pathology (AFIP) Mortuary Affairs. (Tabs X-3, AA-3 through AA-6, Second Addendum Tabs B-18 through B-19)

5. MAINTENANCE

a. Forms Documentation

The 3rd Maintenance Group (3MG), JBER, maintained the aircraft forms for the MA. The F-22A aircraft maintenance records are stored in an electronic management database referred to as the Integrated Maintenance Information System (IMIS). IMIS tracks all scheduled and unscheduled maintenance activities, repairs, aircraft flying hours, maintenance personnel activity, and Technical Order Data (TOD). A detailed 90-day maintenance records review in IMIS was completed. The historical aircraft forms revealed no major documentation errors. (Second Addendum Tabs B-5 through B-6)

b. Inspections

Time Compliance Technical Orders (TCTOs) are inspections or maintenance procedures required before specific dates or flight. No TCTOs restricted the MA from flying. Historical records located in IMIS showed all TCTO accomplishment IAW applicable guidance. There were no overdue component time changes or TCTOs. (Tabs D-7 through D-9, J-34)

The MA flew 31 flights totaling 44.3 hours within 90 days of the mishap. There were no major maintenance discrepancies that would have prevented the MA from accomplishing the training flight on 16 November 2010. Also, historical records did not reveal any recurring or repeating maintenance problems. (Tabs D-4 through D-6, Second Addendum Tabs B-5 through B-6)

A Pre-Flight (PR) is a flight preparedness inspection performed prior to flight and is a valid inspection for 72 hours once completed. The PR inspection is governed by TO 00-20-1 and is performed in accordance with the F-22A PR inspection TO. The purpose of this inspection is to visually inspect and operationally validate various areas and systems of the aircraft in preparation for a flying period. (Second Addendum Tab B-6) The maintenance technician reported no discrepancies on PR performed on 15 November 2010. There is no evidence to suggest that the PR was a factor in the mishap. (Tabs D-4 through D-6)

c. Maintenance Procedures

All documentation of maintenance procedures were reviewed by the maintenance advisors. The most recent major maintenance procedure performed on the MA was the Contract Field Team accomplishment of TCTO 1F-22A-1222 on 5 through 27 October 2010. The TCTO consisted of maintenance performed on both horizontal tail surfaces. There is no evidence to suggest the TCTO actions were a factor in the mishap. (Tab U-5, Second Addendum Tab B-7)

A major maintenance inspection for the F-22A is the Packaged Maintenance Plan (PMP) concept. The PMP is scheduled maintenance tasks determined by airframe hours specified by TO 1F-22A-6. According to TO 1F-22A-6, the first PMP is due at the 900 airframe hour mark. The MA was not due for its first PMP for another 410 hours. There is no evidence to suggest the PMP was a factor in the mishap. (Tab D-3, Second Addendum Tab B-7)

d. Maintenance Personnel and Supervision

All personnel involved in the PR and launch of the MA were experienced and competent. A thorough review of maintenance training records in the electronic Training Business Area revealed all involved personnel were properly trained and qualified. (Tabs G-58 through G-64)

e. Fuel, Hydraulic and Oil Inspection Analyses

The Fuels Laboratory from JBER and Eielson AFB sent fuel samples to the Air Force Petroleum Agency, Wright-Patterson AFB, Ohio, IAW TO 42B-1-1. The two R-11 refuel trucks from JBER and fuel samples taken from the KC-135 aircraft that refueled the MA were sent for testing. All fuel samples were within limits and were satisfactory for use. (Tabs D-25 through D-41)

The following aircraft ground support equipment samples were taken: Polyalphaolefin (PAO), hydraulic, and oil cart. All samples were tested and found to be within limits and satisfactory for use. (Tabs D-21 through D-25)

The impact destroyed both engine reservoirs, gearboxes, and other containers that held PAO, hydraulic, and oil fluid preventing post-impact sample retrieval. (Tabs J-4 through J-6)

f. Unscheduled Maintenance

Review of the maintenance records for the MA indicates that both engines were replaced one week before the mishap by 3MG. The #1 engine (E0123) required removal because the engine oil sample showed high iron during a routine oil analysis sample. The #2 engine (E0316) required removal to complete a heat exchanger time change replacement. The ECS bleed air duct disconnection and reconnection were performed during engine removal and installation tasks. A journeyman technician, a craftsman technician, and a Quality Assurance (QA) inspector performed engine bay inspections on both left and right sides with no defects noted. Following engine installations, a journeyman technician, a craftsman technician, and a QA inspector verified installation with no defects noted. Engine operational checks were accomplished with no maintenance issues reported. (Second Addendum Tabs B-5 through B-6) No other ECS maintenance was performed on the MA within the 90-day maintenance review. (Tab J-34) All maintenance actions were in order, appropriate. There is no evidence to suggest the maintenance actions were a factor in the mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS.

a. Structures and Systems

The high rate of speed at impact destroyed a majority of components from the aircraft. A thorough inspection of all recovered and identified aircraft parts was completed. (Tabs J-4 through J-5)

(1) Crash Survivability Memory Unit (CSMU)

The recovered CSMU was sent to Lockheed Martin Aeronautics Company (LM-Aero) for evaluation. LM-Aero was able to compile a chronological summary of significant events and aircraft system integrity using the CSMU data. (Tabs J-3, J-10, L-3 through L-7)

(2) Flight Control System (FLCS)

The CSMU data indicated normal operation of the FLCS. The Initiated Built-In Test passed prior to flight, and no other fault report codes (FRC) were reported in the mishap CSMU file. (Tab J-14)

The F-22A is equipped with a Low Altitude Warning System (LAWS). The CSMU data showed the LAWS was programmed to alert at 14,000 ft MSL, but the default setting was to the off position, meaning an alert would not sound unless the MP activated the system. Local procedures did not mandate that the MP activate the LAWS, and there was no evidence that the MP activated the system. (Tabs J-14, J-15 and J-36, [First] Addendum Tabs C-3 through C-4, C-8.) The CSMU data showed that the system did not alert and there was no indication of malfunction. (Tabs J-14, J-15 and J-36.)

(3) Electrical Power System (EPS)

The CSMU data indicated normal operation of the EPS. There were no EPS failures throughout the flight. (Tab J-20)

(4) Auxiliary Power Generating System (APGS)

The APGS, via the auxiliary power unit (APU) provides bleed air for use by the ECS and for airframe-mounted accessory drive (AMAD) motoring. A review of the CSMU data indicated normal operation of the APGS. (Tabs J-20, J-22, J-34 through J-35)

(5) Engines

The CSMU data indicated both engines responded to pilot input and operated normally throughout the flight. Both engines were Pratt and Whitney (P&W) F119-PW-100 turbofan engines. The #1 engine (PW0E730305) had 595.5 hours. The #2 engine (PW0E70296) had 685.4 hours. There were no overdue inspections or time changes on either engine. (Tabs D-3, J-21, J-34)

(6) Hydraulic Power System

The CSMU data indicated normal operation of the hydraulic power system. (Tab J-21)

(7) Fuel System

Review of the CSMU data revealed normal fuel system performance as designed during normal flight operations and emergency operations. (Tabs J-21 through J-22)

(8) Environmental Control System (ECS)

When the ECS system IVSC logic detected a manifold bleed air leak, a C BLEED HOT caution ICAW asserted. In this case, the logic commanded all bleed air regulating shutoff valves to close. This action protects against a bleed air induced aircraft fire. Closing all the valves results in the immediate loss of all ECS bleed and conditioned airflow, removing airflow to the OBOGS unit. The air bleed valves will remain closed for the duration of the flight, even if the caution ICAW clears. (Tabs O-13, BB-30) Due to the extensive damage and limited evidence recovered, the cause of the bleed air leak could not be determined. Review of the MA wreckage and CSMU data revealed the ECS performed as designed throughout the flight. (Tab J-22)

(9) Escape System

The CSMU data showed that the canopy was down and the seat armed for the entire MS. Physical evidence of the recovered components indicated the canopy was in the down and locked position, and the ejection sequence was not initiated prior to impact. (Tabs H-5 through H-6, J-35)

(10) Integrated Vehicle Subsystem Controller

The IVSC provides control and/or monitoring of all aircraft utilities and subsystems in a centralized computer system. Based on the recovered CSMU data, all IVSC assemblies appear to have been fully-operational throughout the MS. However, the data contained three Global Manager reported faults:

1. 4622 19 073 – Data Transfer/Mass Memory Video Recorder Not Responding on the Avionics System 1553 Bus 'B'
2. 4622 04 076 – ECS Air Cooled Avionics Manifold Delta Pressure
3. 4622 04 331 – ECS Warm Air Manifold Delta Pressure

The IVSC fault data was analyzed using both the mishap and APU Time History (AT file) data. Based on the analysis of the data, there is no evidence to suggest these faults were a factor in the mishap. (Tabs J-19 through J-20)

b. Evaluation and Analysis

(1) Emergency Oxygen System (EOS)

Analysis was conducted to determine if the EOS was activated prior to ground impact. Various components from the ECS, EOS, and OBOGS were submitted to AFRL/RXSA for evaluation. Based on the report findings, the EOS was most likely not activated. (Tabs J-35, J-68, J-71 through J-74, J-77)

In addition, AFRL/RXSA examined the possibility that the wedge block, which was attached to the EOS activation ring lanyard, was incorrectly installed. This could have been a potential interference with the EOS activation process. (Tab J-72) However, during ground simulation, the AIB pilot advisor was able to manually activate the EOS regardless of whether the wedge block was correctly or incorrectly installed. (Tab U-4 and Figure 15) As such, there is no evidence to suggest the wedge block was a factor in the mishap.

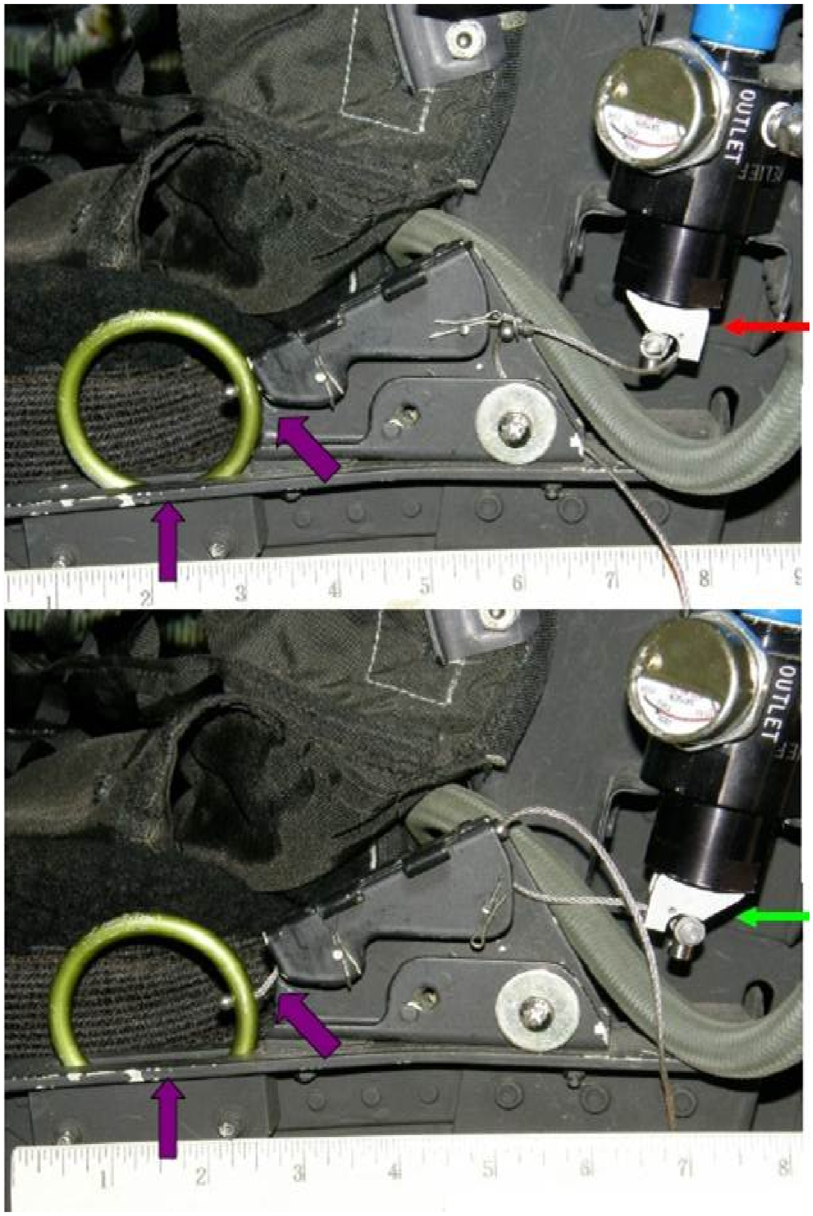

Figure 15 -- The wedge block installed incorrectly (red arrow) and correctly (green arrow). Notice the position of the EOS activation ring within the seat (purple arrows) based on wedge block position. (Tab Z-6)

(2) Canopy Seal/Anti-G suit Air Regulating Valve

The canopy seal/anti G suit regulating valve was recovered and analyzed. This analysis was conducted to determine if the canopy seal and anti-G suit air regulating valve were properly functioning prior to impact. There is no evidence to suggest the valve was a factor in the mishap. (Tabs J-28, J-35, J-147 through J-148, U-6)

(3) On Board Oxygen Generation System

The recovered components of the OBOGS unit were evaluated by the Human System Department, Naval Warfare Center, Patuxent River, Maryland. The purpose of the evaluation was to assess a possible contamination of the OBOGS unit. The OBOGS analysis showed evidence of carbon dioxide that was determined to be insignificant. (Tabs J-63 through J-65) Additionally, the canister test included detection of JP-5, JP-8 and PAO (jet fuels and lubricants). JP-8 jet fuel detected in the sample was considered to be high; however, the canister was found opened and exposed to the environment during the recovery operations. Therefore, secondary contamination was likely. (Tabs J-59 through J-66) There was no evidence to suggest that the OBOGS was contaminated prior to impact.

(4) Gas Chromatograph Analysis

Forensic swab collection was performed on the CRU-94, Breathing Regulator/Anti-G (BRAG) valve, canopy seal/anti-G suit air regulating valve, anti-G suit connector, O2 bulkhead fitting, OBOGS connector fitting, and OBOGS pressure regulator. (Tab J-108 and Second Addendum Tab B-24) These samples were analyzed by the University of Dayton. The BRAG valve dry swab contained the presence of materials that are components of jet fuel. (Second Addendum Tab B-24 The BRAG valve recovery location and exposure to the environment upon impact caused secondary contamination. (Tabs J-71 through J-74, J-137 through J-146, CC-13, Second Addendum Tab B-24) All other components tested were determined to have medically insignificant contaminants. Therefore, there was no evidence to suggest that the Breathing Regulator/Anti-G valve was contaminated prior to impact. (Tab CC-13, Second Addendum Tab B-24)

7. WEATHER

a. Forecast Weather

The weather forecast for JBER on 16 November 2010 predicted a scattered cloud layer at 7,000 ft above ground level (AGL), unlimited visibility, winds at 360 degrees at 12 knots gusting to 18 knots, light turbulence from surface to 3,000 ft, and a minimum altimeter setting of 30.28 inches of mercury. There was a temporary forecast until 18:00L for winds to be 010 degrees at 15 knots gusting up to 18 knots and decreasing to 12 knots at 20:00L. (Tab F-14) Additionally, there were weather warnings for wind gusts at 35 knots but less than 50 knots, and wind shear at 1,500 ft at 040 degrees at 44 knots until 18:00L. (Tab F-3)

The weather forecast in the Dice MOA predicted scattered clouds at 5,000 ft and 10,000 ft AGL, seven statute miles of visibility, winds at 40,000 ft out of the north at 50 knots, and the contrail level from 25,000 to 39,000 ft. The moonrise was at 14:34L, and the illumination was 74%. (Tab F-3)

b. Observed Weather

The observed weather at JBER at takeoff was as follows: winds at 030 degrees at 17 knots gusting up to 21 knots, 10 miles of visibility, clear skies, and a minimum altimeter setting of 30.42 inches of mercury. (Tab F-5) According to Jake 03, there was no adverse weather in the airspace with clear skies, good illumination, and "one of the nicest" nights of the winter. (Tabs R-45 through R-46)

c. Space Environment

Not applicable.

d. Operations

Weather did not affect operations and there is no evidence to suggest weather was a factor in the mishap.

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was a current and qualified IP and mission commander (MC) with 303.5 hours in the F-22A, including 98.1 hours as an IP, and 761.9 total hours in fighter aircraft. Prior to his assignment to the F-22A, the MP accumulated 416 hours in the F-15C/D. The MP had 31.4 NVG hours in the F-22A, 40.2 total NVG hours, and 47.6 total night hours. (Tabs G-3, G-10 through G-12)

The MP was recognized throughout his career for exceptional performance. He received numerous accolades and awards including: Distinguished Graduate, AETC Commanders Trophy winner, and Flying Excellence Award winner from Undergraduate Pilot Training; Top Overall Graduate and Distinguished Graduate from F-15C Fighter Training; and most recently, 525FS Flight Lead of the Year, Warrior of the Year, Turkey Shoot Top Flight Lead, Instructor Pilot of the Quarter, and selection as an alternate to the F-22A Weapons Instructor Course. He was regarded as one of the top pilots in the squadron among his peers and supervisors. (Tabs R-22 through R-23, R-39 through R-40, R-77, R-88, T-3, V-9.5 through V-9.6, V-10.5)

The MP flew four sorties in the two weeks prior to the mishap, two of which were night missions with NVGs. The MP flew on 15 November 2010, the night prior to the mishap. (Tab G-10)

The MP's flight time and sortie count during the 90 days before the mishap are as follows:

	Hours	Sorties
Last 30 Days	8.1	5
Last 60 Days	18.6	13
Last 90 Days	29.7	21

(Tabs G-56 through G-57)

There is no evidence to suggest the MP's qualifications were a factor in the mishap.

b. Mishap Flight Lead

At the time of the mishap, the MFL was a current and qualified FL and MC with 272.8 hours in the F-22A, and 854.2 total hours in fighter aircraft. Prior to his assignment to the F-22A, the MFL accumulated 553.1 hours in the F-15B/C/D. The MFL had 18.4 NVG hours in the F-22A, 57.4 total NVG hours, and 69.4 total night hours. (Tabs G-3, G-30 through G-31)

The MFL flew three sorties in the two weeks prior to the mishap, two of which were night missions with NVGs. The MFL flew on 15 November 2010, the night prior to the mishap. (Tab G-28)

The MFL's flight time and sortie count during the 90 days before the mishap are as follows:

	Hours	Sorties
Last 30 Days	7.7	4
Last 60 Days	16.2	11
Last 90 Days	27.6	20

(Tabs G-56 through G-57)

There is no evidence to suggest the MFL's qualifications were a factor in the mishap.

9. MEDICAL

a. Qualifications – MP

A review of the MP's medical record showed he was medically qualified for flight and worldwide duty. His most recent Periodic Health Assessment was performed on 23 November 2009. No waivers were identified. (Tab X-3)

b. Health – MP

Medical records and individual history revealed the MP was in good health. After thoroughly reviewing the material described above, there is no evidence to suggest any preexisting medical condition was a factor in the mishap. (Tabs X-3, CC-14)

c. Pathology

The remains of the MP were recovered and positively identified. Injuries sustained by the MP were consistent with the nature of the mishap. The MP died instantly upon impact. (Tabs X-3, CC-14, and Second Addendum Tab B-23)

Toxicology testing was performed on the MP, MFL, 71 ground crew (two life support and 69 ground support personnel). Samples were submitted to the AFIP for analysis. All results were negative with the exception of one civilian and one active duty maintenance member who each tested positive for a single substance. Further investigation revealed both individuals held valid prescriptions and appropriate diagnoses for the medication detected during testing. There is no evidence to suggest drug use was a factor in the mishap. (Tabs CC-12, CC-14)

d. Lifestyle – MP

There is no evidence to suggest MP's lifestyle was a factor in the mishap. (Tab CC-14)

e. Crew Rest and Crew Duty Time

All Air Force pilots are required to have "crew rest" IAW AFI 11-202, Vol. 3, prior to performing in-flight duties. AFI 11-202 states, in part, that Air Force aircrews require at least 10 hours of continuous restful activities including an opportunity for at least 8 hours of uninterrupted sleep during the 12 hours immediately prior to the FDP (Flight Duty Period). The crew rest period is normally a minimum 12-hour non-duty period before the FDP begins. Its purpose is to ensure the aircrew member is adequately rested before performing flight or flight related duties. Crew rest is free time, which includes time for meals, transportation, and rest. Rest is defined as a condition that allows an individual the opportunity to sleep. (Second Addendum Tabs E-22 through E-24)

There is no evidence to suggest inadequate crew rest was a factor in the mishap. (Tabs R-139 through R-154, CC-14)

10. OPERATIONS AND SUPERVISION

a. Operations

The 525FS did not have an elevated operations tempo in the month leading up to the mishap. (Tabs R-50, R-66, R-101, V-9.5, V-12.9, V-14.4, V-15.4) The squadron had completed a Unit Compliance Inspection in October 2010 and was not scheduled to deploy until January 2011.

(Tabs R-128, R-143 through R-144) Multiple witnesses described the operations tempo as average and asserted that it did not negatively affect their ability to perform the mission. There is no evidence to suggest operations tempo was a factor in the mishap. (Tabs R-50, R-66, R-101, V-9.5, V-12.9, V-14.4, V-15.4)

b. Supervision

Prior to 19:42:18L, when the C BLEED HOT caution ICAW asserted, the MS was flown as scheduled and planned with only minor deviations due to a delayed takeoff. (Tab R-158) Jake 03 (525FS commander) noted that all safety of flight items were covered thoroughly in the mission brief. There is no evidence to suggest supervision was a factor in the mishap. (Tab R-53)

11. HUMAN FACTORS

AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, Attachment 5, contains the Department of Defense Human Factors Analysis and Classification System, which lists potential human factors that can play a role in aircraft mishaps. (Tab BB-5 through BB-16, Second Addendum Tabs E-3 through E-7) The following human factors were relevant to the mishap:

a. Organizational Training Issues/Programs (OP004)

Organizational Training Issues/Programs are a factor when one-time or initial training programs, upgrade programs, transition programs or other training that is conducted outside the local unit is inadequate, unavailable, etc. creating an unsafe situation. Failure of an individual to absorb the training material in an adequate training program does not indicate a training program problem. (Second Addendum Tab E-14)

United States Air Force aircrew are highly trained to handle multiple and/or severe aircraft emergencies. The MP had recently reviewed the C BLEED HOT caution ICAW emergency procedures during monthly Supervised Emergency Procedure Training (SEPT) on 2 November 2010. (Tabs G-46, O-9, O-13) However, emergency procedure simulator/ground training does not expose the pilot to all in-flight, real-world stressors and cockpit conditions, such as those experienced in this situation (for example, CAT III cold weather gear, NVG usage, G-forces, cockpit pressurization, motion or restricted breathing). (Tab R-95, Second Addendum Tabs B-8 through B-9) Additionally, the F-22A simulator presented a C BLEED HOT malfunction and associated ICAWs concurrently, which is different than the ICAW presentation timing in an actual aircraft. (Second Addendum Tab B-3)

Nonetheless, TO 1F-22A-1 guidance and procedures, SEPT and simulator training all encourage immediate EOS activation during oxygen system related emergency procedures (for example, “Emergency Oxygen – Activate” is the first step in the C BLEED HOT caution ICAW checklist procedure.) (Tab BB-17, Second Addendum Tab B-3) As such, pilots are predisposed to activate the EOS when experiencing physiological symptoms, based on training and

TO1F-22A-1 checklist procedures. (Second Addendum Tab B-3) Therefore, there is evidence to suggest that Organizational Training Issues/Programs were a factor in the mishap.

b. Personal Equipment Interference (PE207)

Personal Equipment Interference is a factor when the individual's personal equipment interferes with normal duties or safety. (Second Addendum Tab E-10)

The AIB conducted multiple ground simulations of the mishap sequence. The simulations were conducted with the pilot advisor in an actual F-22A cockpit. The pilot advisor is of similar build and size as the MP, and wore the same types of CAT III cold weather gear, life support equipment and NVGs as the MP wore during the MS. All harnesses, safety restraints and life support equipment were connected and secure. (Tabs H-53 through H-56, R-48, U-4 and CC-5) The pilot advisor performed multiple repetitions of reaching for, visually locating, activating, and dropping the EOS activation ring. (Tab CC-5) The EOS activation ring is seated on the left aft edge of the ejection seat. (Figure 15, above)

With the canopy up during the ground simulation, the pilot advisor was able to successfully pull the EOS activation ring. The pilot advisor also simulated what could have occurred if the MP had difficulty pulling and subsequently dropped the EOS activation ring between the seat and the console. The pilot advisor had significant difficulty retrieving the dropped EOS activation ring while wearing cold weather gloves. The pilot advisor also could not visually locate the EOS activation ring without twisting his torso due to the bulky flight gear and EOS activation ring's design, size and location. (Tabs R-85 through R-86, CC-5, [First] Addendum Tabs C-3 through C4, Second Addendum Tabs B-8 through B-10) When the pilot advisor lowered the canopy and performed the same actions with NVGs donned, the AIB members noted that the NVGs impacted the canopy when the pilot advisor moved his head to visually locate the EOS activation ring. (Tabs U-4 and CC-5)

Ground simulations demonstrated reduced mobility in the cockpit due to the bulkiness of CAT III gear. Additionally, the NVGs hit the canopy, interfering with the pilot advisor's ability to look from side to side and down at the consoles. Therefore, there is evidence to suggest that Personal Equipment Interference was a factor in the mishap. (Tab CC-5)

c. Controls and Switches (PE204)

Controls and Switches is a factor when the location, shape, size, design, reliability, lighting, or other aspect of a control or switch is inadequate and this leads to an unsafe situation. (Second Addendum Tab E-10)

The AIB examined the process of manually activating the EOS. The TO 1F-22A-1 states: "To manually activate the EOS, pull the green ring up and out of the retaining slot (approximately 33 pound pull), then pull directly forward minimizing inboard/outboard and upward motion. The pull force required to activate the EOS may be in excess of 40 lbs. The green ring will travel approximately two inches and will not release from the seat side. There is no obvious detent to indicate that the EOS has been activated." (Second Addendum Tab D-5)

During ground simulation, the pilot advisor successfully manually activated the EOS. The pilot advisor also unseated the EOS activation ring and dropped it between the seat and console prior to EOS activation. This was done to simulate a failed initial pull, which may have occurred. Retrieval of the ring from between the seat and console would be difficult based on the seat position, night environment, CAT III cold weather gear, and NVGs. (Tab CC-5, and Figures 16 and 17)

Figure 16 -- Pilot advisor pulling EOS activation ring. NVGs interfering with EOS activation ring visualization.
(Tabs Z-7, CC-5)

Figure 17 -- Manual EOS activation ring fallen below lip of seat.
(Tabs Z-8, CC-5)

Therefore, there is evidence to suggest that the design, size and location of the EOS activation ring were factors in the mishap.

d. Inadvertent Operation (AE101)

Inadvertent Operation is a factor when individual's movements inadvertently activate or deactivate equipment, controls, or switches when there is no intent to operate the control or device. This action may be noticed or unnoticed by the individual. (Second Addendum Tab E-8)

At 19:42:53L, the MP input a combination of right forward stick and right pedal, which initiated a 240-degree descending right roll at greater than 45 degrees per second. (Tab EE-3 and Figure 4, above) At the completion of these stick and pedal inputs at 19:43:08L, the MA had rolled through inverted flight, experienced less than 1-G of gravitational force, and went from a RWD to LWD attitude, and the descent rate of the aircraft significantly increased. (Tab EE-3 and Figure 5, above)

The AIB determined these control inputs to be inadvertent because they had no clear goal or objective, resulted in an unusual attitude, and do not reflect expected or intentional inputs consistent with basic aircraft control. During ground simulations, the AIB observed that the pilot advisor made similar inadvertent control stick and pedal movements while twisting his torso to visually locate the EOS activation ring. (Tab CC-5) Therefore, there is evidence to suggest that inadvertent operation was a factor in the mishap.

e. Channelized Attention (PC102)

Channelized attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. This factor may be described as a tight focus of attention that leads to the exclusion of comprehensive situational information. (Second Addendum Tab E-11)

The following evidence indicates the MP initially exhibited channelized attention while attempting to restore oxygen flow IAW his training and checklist procedures. The first step in the C BLEED HOT caution ICAW checklist is "Emergency oxygen – Activate," a procedure recently reviewed by the MP during the monthly SEPT on 2 November 2010. (Tabs G-46, O-13, BB-17) Additionally, the OBOGS FAIL caution ICAW checklist warns pilots to activate the EOS if they experience any physiological symptoms. (Tab BB-28) As such, pilots are predisposed to activate the EOS when experiencing physiological symptoms, based on training and TO 1F-22A-1 checklist procedures. (Second Addendum Tab B-3)

At 19:42:37L, airflow to MP's oxygen mask stopped, which would have caused a restricted breathing condition. The MP most likely experienced a sense similar to suffocation. (Tab J-13, Second Addendum Tab B-4) This restricted breathing condition would not have been incapacitating, but would have been a physiological symptom prompting him to immediately activate the EOS, based on his training and TO 1F-22A-1 checklist procedures. (Second Addendum Tab B-4) However, post-mishap forensic evidence indicated that the EOS was most likely not activated. (Tabs J-76 through J-77)

Additionally, at 19:42:53L, the MP input a combination of right forward stick and right pedal, which initiated a 240-degree descending right roll at greater than 45 degrees per second. (Tab EE-3 and Figure 4, above) By 19:43:08L, the MA had rolled through inverted flight, experienced less than 1-G of gravitational force, went from a RWD to LWD attitude, and the descent rate of the aircraft significantly increased. (Tab EE-3 and Figure 5, above) The roll rate and change in gravitational force were above the minimally detectable threshold and should have been recognized by the MP. (Tab CC-3) These flight control inputs do not reflect expected or intentional inputs consistent with basic aircraft control.

There is evidence to suggest that the MP initially channelized his attention on restoring oxygen flow while attempting to manually activate the EOS. When the airflow stopped to the MP's oxygen mask, the MP tightly focused his attention inside the cockpit. This may have precluded the MP from perceiving the detectable attitude changes and corresponding unusual attitude. (Tabs J-13, J-43, J-76 through J-77, CC-3, CC-5, Second Addendum Tabs B-3 through B-4, B-8 through B-9)

f. Breakdown in Visual Scan (AE105)

Breakdown in visual scan is a factor when the individual fails to effectively execute learned/practiced internal or external visual scan patterns. The breakdown can lead to an unsafe situation. (Second Addendum Tabs E-8 through E-9)

At 19:42:45L, the evidence suggests that intentional flight control inputs stopped and did not resume for approximately 39 seconds. (Tab EE-3 and Figure 3, above) However, during this period, at 19:42:53L, the MP input a combination of right forward stick and right pedal, which initiated a 240-degree descending right roll at greater than 45 degrees per second. (Tab EE-3 and Figure 4, above) By 19:43:08L, the MA had rolled through inverted flight, experienced less than 1-G of gravitational force, went from a RWD to LWD attitude, and the descent rate of the aircraft significantly increased. (Tab EE-3 and Figure 5, above) In a single-seat aircraft, the pilot is solely responsible for maintaining aircraft control while managing other cockpit tasks. A continuous cross-check of in-flight parameters via cockpit instruments or outside references is essential. Had the MP focused on the flight instruments or looked outside (based on high moon illumination and a discernible horizon), the MP would have recognized the change in aircraft orientation and made corrective flight control inputs. (Tabs F-3, R-6, and R-84, CC-3) Since the MP did not take corrective action until below the minimum dive recovery altitude, there is evidence to suggest that breakdown in visual scan was a factor in the mishap.

g. Spatial Disorientation (Type 1) Unrecognized (PC508)

Spatial Disorientation is a failure to correctly sense a position, motion, or attitude of the aircraft or of oneself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. Spatial Disorientation (Type 1) Unrecognized is a factor when a person's cognitive awareness of one or more of the following varies from reality: attitude, position, velocity, direction of motion or acceleration. Proper control inputs are not made because the need is unknown. (Second Addendum Tab E-14)

IAW the OBOGS FAIL checklist, the MP was in a deliberate and controlled descent to a lower altitude after the assertion of the OBOGS FAIL caution ICAW. (Tab BB-29) However, at 19:42:53L the MP input stick and pedal movements for approximately 15 seconds, causing a 240-degree descending right roll. (Tab EE-3 and Figure 3, above) At the completion of these stick and pedal inputs at time 19:43:08L, the MA had rolled through inverted flight, experienced less than 1-G of gravitational force, transitioned from a RWD to LWD attitude, and significantly increased the descent rate. (Tab EE-3 and Figure 5, above) This increased descent rate shortened the amount of time available to recover the aircraft. The MP did not take corrective actions until approximately three seconds prior to impact. By the time the MP recognized the unusual attitude and applied dive recovery flight control inputs, the MA had transitioned below the minimum safe recovery altitude. (Tabs J-19, EE-3 and Figure 8, above)

The AIB determined the MP lost cognitive awareness of the MA's location and orientation relative to the ground, and he did not make proper control inputs because the need was unknown, until it was too late. Therefore, there is evidence to suggest that unrecognized spatial disorientation was a factor in the mishap. (Tabs J-19, EE-3 and Figure 8, above)

Although non-contributory to the mishap, the following human factors warrant discussion: Hypoxia, Effects of G Forces (G-LOC, etc.), and Sudden Incapacitation/Unconsciousness.

h. Hypoxia (PC312)

Hypoxia is a factor when the individual has insufficient oxygen supply to the body sufficient to cause an impairment of function. (Second Addendum Tab E-13)

The AIB examined the possibility that the MP suffered from any form of hypoxia during the MS. There are four forms of hypoxia; anemic, histotoxic, hypoxic and stagnant:

Anemic hypoxia is a reduction in the oxygen carrying capacity of the blood. Causes include carbon monoxide poisoning, hemorrhage, reduced hemoglobin concentration, and increased red cell destruction/decreased red cell production. In aerospace medicine, the most feasible concern is carbon monoxide poisoning. The data recovered from the MA showed there was no evidence of carbon monoxide contamination in the MP's air supply. There was insufficient tissue for a toxicological assessment for carbon monoxide in the MP. Finally, review of the MP’s medical record did not identify any evidence to support other possible causes. Therefore, because the MP was able to pull over 7-Gs prior to impact, there is no evidence to suggest that anemic hypoxia was a factor in the mishap. ([First] Addendum Tab C-6)

Histotoxic hypoxia is the inability of cells to take up or utilize oxygen from the bloodstream, despite physiologically normal delivery of oxygen to such cells and tissues. Histotoxic hypoxia results from tissue poisoning, caused by oxygen toxicity and/or cyanide. Oxygen toxicity is caused by breathing 100% oxygen for 24 hours or more, or breathing 100% oxygen at increased ambient pressure, neither of which was present during the MS. There was no apparent mechanism for exposing the MP to cyanide during the MS. Therefore, there is no evidence to suggest that histotoxic hypoxia was a factor in the mishap. ([First] Addendum Tab C-6)

Hypoxic hypoxia occurs when the oxygen tension in the arterial blood becomes insufficient for normal function. ([First] Addendum Tab C-5) The MP was operating at high altitude for a majority of the MS, based on the F-22A cabin pressurization schedule, the cockpit altitude would not have exceeded 23,000 ft. (Tab EE-3, [First] Addendum Tabs C-5 and C-7) Additionally, based on the F-22A oxygen concentration schedule, the MP would have been breathing 90% to 94% oxygen. This would have caused his body to have a high oxygen saturation level prior to the MA malfunction. (Second Addendum Tabs B-11 through B-14) The recovered CSMU data showed no EOS fault codes prior to 19:42:23L, when the OBOGS FAIL caution ICAW asserted. (Tab J-12) Therefore, the evidence suggests that prior to the OBOGS FAIL caution ICAW, the OBOGS system was functioning as designed, and the MP would not have been incapacitated due to hypoxic hypoxia. (Tab J-22, [First] Addendum Tabs C-5 and C-7)

The MP was at high altitude requiring supplemental oxygen when the bleed air malfunction occurred and would have had the oxygen mask secured to ensure proper oxygen concentration flow IAW his training and AFI 11-202, Vol. 3, Paragraph 6.4, Table 6.2. (Second Addendum Tabs E-18 through E-20) At 19:42:37L, airflow to MP's oxygen mask stopped, which would have caused a restricted breathing condition. The MP most likely experienced a sense similar to suffocation. (Tab J-13, Second Addendum Tab B-4) This restricted breathing condition would not have been incapacitating, but would have been a physiological symptom prompting him to immediately activate the EOS, based on his training and TO 1F-22A-1 checklist procedures. (Second Addendum Tab B-4) Activation of the EOS would have restored oxygen flow to the MP's oxygen mask. (Tab J-43) However, as previously discussed, the EOS was most likely not activated. (Tabs J-12, J-68, J-76 through J-77) Therefore, the AIB had to determine whether the MP suffered a hypoxic event during the mishap sequence after the airflow to the MP's oxygen mask stopped. The AIB considered two scenarios: (1) the MP lowered or partially lowered his mask to take a breath; or (2) the MP kept his mask secure and held his breath for the duration of the mishap sequence.

(1) If the MP lowered or partially lowered his mask by releasing one mask bayonet or simply pulling the mask away from his face, he would have been breathing cockpit air. Based on the cabin pressurization schedule and CSMU data, the cockpit altitude never exceeded 23,000 ft during the mishap sequence of events. (Tabs J-12 through J-13, J-25 through J-27, [First] Addendum Tabs C-5 and C-7, Second Addendum Tab B-4) According to research, the MP would have more than three to five minutes of time of useful consciousness (TUC) at that cockpit altitude. (Tab CC-6, [First] Addendum Tabs C-5 and C-7) Additionally, the cockpit altitude continued to decrease throughout the mishap sequence of events as the MA descended to lower altitude, allowing a longer TUC. ([First] Addendum Tab C-5) Therefore, the evidence suggests that the MP would not have been incapacitated due to hypoxic hypoxia in this scenario.

(2) The AIB also examined the scenario where the MP kept his mask secure and did not take a breath for the duration of the mishap. Given the oxygen concentration schedule and the high affinity of oxygen to hemoglobin (oxygen-carrying molecule in the blood), the MP's body would have been highly saturated with oxygen. This would have substantially increased the MP's breath holding time and reduced his respiratory drive. A reduced respiratory drive would enable the MP to endure a breathing restriction/suffocation by increasing his TUC. Based on the conditions, analysis showed that the MP, at a minimum, had approximately 68 seconds of breath holding time following the airflow shutoff to the MP's oxygen mask. (Second Addendum Tabs B-11 through B-13) Although the mishap sequence of events from the assertion of the C BLEED HOT caution ICAW to impact was 69 seconds, the time from airflow shut-off to impact was only 50 seconds. (Tabs J-4, J-13, J-43, EE-3) Therefore, the evidence suggests that the MP would not have been incapacitated due to hypoxic hypoxia in this scenario.

Stagnant hypoxia is the reduction in blood flow to the body's tissues. Causes of stagnant hypoxia include exposure to cold temperatures and sustained exposure to high accelerations (for example, pilots performing high-G turns). Evidence collected from the crash site indicated the MP was appropriately wearing the required cold weather gear during the MS, and therefore stagnant hypoxia due to cold exposure is unlikely. ([First] Addendum Tabs C-5 through C-6) CSMU data from the last few minutes of flight indicated the MA was not in a high-G environment until the 7.4-G recovery pull three seconds prior to impact. (Tab EE-3) There is no evidence to suggest that stagnant hypoxia was a factor in the mishap. (Tab EE-3, [First] Addendum Tabs C-5 through C-6)

i. Effects of G Forces (G-LOC, etc.) (PC301)

Effects of G Forces (G-LOC, etc) is a factor when the individual experiences G-induced loss of consciousness (GLOC), greyout, blackout or other neurocirculatory affects of sustained acceleration forces. (Second Addendum Tab E-12)

The AIB considered the possibility that the MP suffered the effects of G Forces during the mishap sequence to include almost loss of consciousness (A-LOC). A-LOC "consists of a transient incapacitation without complete loss of consciousness that often occurs during and after relatively short-duration, rapid-onset gravitational forces." (Second Addendum Tab B-16)

The MP was a highly trained and experienced pilot familiar with, and physiologically conditioned to, the effects of high-G maneuvering. The AIB reviewed the MP's centrifuge training tape that demonstrated the MP had an adequate anti-G strain technique and a resting G tolerance of 4.8-Gs. (Tabs G-3, O-3, T-3, CC-10 through CC-11)

Based on recovered data, prior to the aircraft malfunction, the MA was flying a low-G forces profile while attempting to rejoin with the MFL. (Tab EE-3) During the mishap sequence of events, the MA did not exceed 2.5-Gs prior to the 7.4-G attempted dive recovery three seconds prior to impact. Therefore, there is no evidence to suggest that G Forces were a factor in the mishap. (Tabs EE-3, Second Addendum Tab B-16, and Figure 8, above)

j. Sudden Incapacitation/Unconsciousness (PC304)

Sudden Incapacitation/Unconsciousness is a factor when the individual has an abrupt loss of functional capacity / conscious awareness. (NOT GLOC) (Second Addendum Tab E-12)

The AIB considered the possibility that the MP suffered sudden incapacitation/unconsciousness. The most reasonable causes of sudden incapacitation include: cardiovascular events (i.e. heart attack), neurologic events (i.e. seizure), and increased age (i.e. above 50 years old). (Second Addendum Tabs B-15 through B-17) The MP's age at the time of the mishap was well below the threshold for the age associated sudden incapacitation. (Second Addendum Tab B-16) Additionally, the AIB medical advisor documented that the MP was medically qualified for flight duty and had no information in his medical record that would indicate that the MP would have been susceptible to either cardiac or neurologic events leading to disqualification from flight duties. (Tabs X-3, CC-14, Second Addendum Tab B-16)

Further, the AIB referred to a medical review published in 1991 by McCormick and Lyons titled *Medical causes of in-flight incapacitation: USAF experience 1978-1987*. (Second Addendum

Tabs B-15 through B-17) In this publication, the analysis included an examination of 23 in-flight incidents of incapacitation due to significant underlying medical conditions, such as the aforementioned causes of sudden incapacitation. The researchers calculated a frequency of incapacitating events to be 0.19 events per 1,000,000 flying hours. Given the MP's total flying hours was 959.7 hours, this resulted in a 0.018% probability that the MP suffered from incapacitation during the final moments of the MS. (Tab G-12, Second Addendum Tab B-16)

The evidence suggests the MP was conscious and actively flying the MA throughout the MS. At the assertion of the OBOGS FAIL caution ICAW until 19:42:45L, the MP retarded the throttles to IDLE power and deliberately continued a controlled, descending right hand turn to descend to a lower altitude IAW the checklist. (Tabs BB-29, EE-3, and Figures 3 and 4, above) While there are 39 seconds when the MP appears to not be deliberately controlling the MA, the MP executed a 7.4-G dive recovery maneuver three seconds prior to impact demonstrating the MP was conscious and positively controlling the MA at the time of impact. There is no evidence that the MP suffered an unconscious event during the 39 seconds, regained consciousness, and then attempted to recover the MA. (Second Addendum Tabs B-15 through B-17)

Therefore, there is no evidence to suggest that sudden incapacitation/unconsciousness was a factor in the mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Available Directives and Publications Relevant to the Mishap

(1) Air Force Policy Directive (AFPD) 11-2, Aircraft Rules and Procedures, 14 January 2005
(2) AFI 11-202, Volume 3, *General Flight Rules, Flying Operations*, 5 April 2006
(3) AFI 11-401, *Aviation Management*, 7 March 2007
(4) AFI 91-204, *Safety Investigations And Reports*, 24 September 2008 and Attachment 5 - Department of Defense Human Factors Analysis and Classification System
(5) AFI 90-901, *Operational Risk Management*, *Command Policy*, 1 April 2000
(6) AFPAM 11-419, *G-Awareness for Aircrew*, 1 December 1999, certified current 29 January 2010

b. Other Directives and Publications Relevant to the Mishap

(1) AETC Handout, *Flying Training*, *Introduction to Aerodynamics*, January 2002
(2) Air Force Handbook 203, Volume 1, *Flying Operations, Weather for Aircrews*, 1 March 1997
(3) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, And Procedures*, 30 April 2003, Change 4 - 1 September 2006
(4) TO 1F-22A-1, *Flight Manual F22A Raptor,* 3 September 2007, change 6 20 September 2010

NOTICE: The AFIs listed above are available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil**.

c. Known or Suspected Deviations from Directives or Publications

None

13. ADDITIONAL AREAS OF CONCERN

None

JUN -7 2013

JAMES S. BROWNE, Brig Gen, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

F-22A, T/N 06-4125
JOINT BASE ELMENDORF-RICHARDSON, ALASKA
16 NOVEMBER 2010

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

On 16 November 2010, at approximately 19:43:27 hours local time (L), an F-22A, Tail Number 06-4125, assigned to the 525th Fighter Squadron, 3rd Wing, Joint Base Elmendorf-Richardson (JBER), Alaska, impacted the ground during controlled flight approximately 120 nautical miles (NM) north of JBER. The mishap pilot (MP) did not attempt ejection and was fatally injured upon impact. The mishap aircraft (MA) impacted near the edge of a valley floor in the Talkeetna Mountain range and was destroyed.

The mishap occurred on a 3-ship night opposed surface attack tactics (SAT) training mission. Opposed SAT missions typically consist of F-22As fighting their way into a target area protected by enemy forces and dropping Joint Direct Attack Munitions (JDAM) on specified targets. During the return-to-base portion of the mission while the MP was attempting to rejoin with his flight lead, the MA experienced an engine bleed air leak malfunction at 19:42:18L. At approximately 19:42:37L, airflow to MP's oxygen mask stopped. At 19:42:53L, the MP entered a 240-degree roll through inverted flight, and the nose down (ND) pitch attitude increased. At approximately 19:43:24L, the MP initiated a dive recovery. Three seconds later, the MA impacted the ground in a left bank at approximately 48 degrees ND at a speed greater than 1.1 Mach (M).

By clear and convincing evidence, I find the cause of the mishap was the MP's failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan and unrecognized spatial disorientation.

By preponderance of the evidence, I also find organizational training issues, personal equipment interference, controls and switches, and inadvertent operation were factors that substantially contributed to the mishap.

I developed my opinion by analyzing factual data from historical records, Air Force directives and guidance, engineering analysis, witness testimony, and information provided by technical experts. The AIB obtained an animation provided by the Aeronautical Systems Center Studies & Analysis Division. I used the animation in conjunction with Lockheed Martin engineering analysis and crash survivable memory unit (CSMU) data to determine the mishap sequence of events. In addition, I evaluated the information contained within the Task Force Report, as directed by the Convening Authority.

2. DISCUSSION OF OPINION

During the mishap sortie, a chain of events triggered by an aircraft bleed air malfunction ultimately led to the MP's attempt at an untimely dive recovery prior to impacting the ground. The CSMU data provided clear and convincing evidence of the MA's control and performance flight data to support the cause of the mishap. Organizational training issues, personal equipment interference, controls and switches, and inadvertent operations substantially contributed to three cascading causal factors: channelized attention, breakdown of visual scan and unrecognized spatial disorientation (terms defined by the Department of Defense Human Factors Analysis and Classification System).

The MP was an outstanding and experienced aviator, who was highly regarded by his supervisors and peers. The MP was current, qualified and mentally/physically fit for the MS. The MS was a night mission employing night vision goggles (NVGs) and the first mission of the cold weather season requiring the MP to wear Category III (CAT III) cold weather gear. During the return-to-base portion of the MS, the MA experienced a bleed air malfunction.

At 19:42:18L, a C BLEED HOT caution Integrated Caution, Advisory and Warning (ICAW) asserted, indicating a bleed air leak in the center bleed air ducting from both engines. The MA functioned as designed when it responded to the warning, and automatically shut down five functions: the Environmental Control System, the Air Cycle System forced air cooling, the On-board Oxygen Generating System (OBOGS), the On-Board Inert Gas Generating System and Cabin Pressure. These actions were automatic, programmed responses to protect against a bleed air induced aircraft fire. Based on the recovered CSMU data, the flight control system and both engines were operating normally and responding to pilot inputs despite the loss of the aforementioned functions.

At 19:42:21L, the C BLEED HOT caution ICAW cleared. At 19:42:23L, the OBOGS FAIL caution ICAW asserted based upon the bleed air shut down to the OBOGS. According to TO 1F-22A-1, a caution ICAW message warns of an "[a]ircraft operation that could result in damage to the aircraft. Corrective procedures may be required, but not immediately." The MP appropriately responded, initiated a reduction in power and entered a controlled, right-hand, 30-degree nose-down descent. This intentional attitude and descent rate were consistent with his training and checklist guidance. This would have allowed the MP time to execute the emergency procedures with some heads-down and hands-off-the-controls time to take necessary actions in the cockpit.

Given the aforementioned conditions, responding to an aircraft malfunction would have been challenging, but the MP was highly trained to handle complex aircraft emergencies. The MP had recently reviewed the C BLEED HOT caution ICAW emergency procedures during monthly Supervised Emergency Procedure Training (SEPT) on 2 November 2010. However, emergency procedure simulator/ground training does not expose the pilot to all in-flight, real-world stressors and cockpit conditions, such as those experienced in this situation (for example, CAT III cold weather gear, NVG usage, G-forces, cockpit pressurization, motion or restricted breathing). Additionally, the F-22A simulator presented a C BLEED HOT malfunction and associated ICAWs concurrently, which is different than the ICAW presentation timing in an actual aircraft. Therefore, I find, by a preponderance of the evidence, that Organizational Training Issues/Programs were a substantially contributing factor in the mishap.

The MP was at high altitude requiring supplemental oxygen when the bleed air malfunction occurred, and he would have had the oxygen mask secured to ensure proper oxygen concentration flow in accordance with his training and AFI 11-202, Vol. 3, Paragraph 6.4, Table 6.2. At approximately 19:42:37L, airflow to the MP's oxygen mask stopped, which would have caused a restricted breathing condition. The MP most likely experienced a sense similar to suffocation.

At this point, had the MP lowered or partially lowered his mask by releasing one mask bayonet or simply pulled the mask away from his face, he would have been breathing cockpit air. Based on the cabin pressure schedule and CSMU data, the cockpit altitude never exceeded 23,000 feet during the mishap sequence of events. The MP would have more than three to five minutes of time of useful consciousness (TUC) at that cockpit altitude. Additionally, the cockpit altitude continued to decrease as the MA descended to lower altitude, allowing a longer TUC. However, based on direct and indirect evidence available, the AIB determined that the MP kept his mask up and secured throughout the mishap sequence of events.

Given the oxygen concentration schedule and the high affinity of oxygen to hemoglobin, the MP's body would have been highly saturated with oxygen. This would have substantially increased the MP's breath holding time and reduced his respiratory drive. A reduced respiratory drive would enable the MP to endure a breathing restriction/suffocation by increasing his TUC. Based on the conditions, analysis showed that the MP, at a minimum, had approximately 64 seconds of breath holding time following the airflow shutoff to the MP's oxygen mask. The mishap sequence of events from airflow shut-off to impact was 50 seconds.

With the mask secured, the restricted breathing condition would not have been incapacitating and would not have prevented him from maintaining aircraft control. It would have been a physiological symptom prompting him to immediately activate the EOS. TO 1F-22A-1 guidance and procedures, SEPT and simulator training all encourage immediate EOS activation during oxygen system related emergency procedures (for example, "Emergency Oxygen – Activate" is the first step in the C BLEED HOT caution ICAW checklist procedure.) As such, pilots are predisposed to activate EOS when experiencing physiological symptoms, based on training and TO 1F-22A-1 checklist procedures.

The EOS activation ring is seated on the left aft edge of the ejection seat. The pilot must unseat the ring and pull directly forward with a force that may be in excess of 40 pounds. The ring travels approximately two inches and remains connected to the seat via a lanyard.

Locating and manually pulling the EOS activation ring would have been difficult under the conditions of the MS. The AIB conducted multiple ground simulations of the mishap sequence with the pilot advisor in an actual F-22A cockpit. The pilot advisor is of similar build and size as the MP, and wore the same types of CAT III cold weather clothing, life support equipment, and NVGs as the MP wore during the MS. All harnesses, safety restraints, and life support equipment were connected and secure. The pilot advisor performed multiple repetitions of reaching for, visually locating, activating, and dropping the EOS activation ring.

During ground simulation, the pilot advisor was able to successfully pull the EOS activation ring. The pilot advisor also simulated what could have occurred if the MP had difficulty pulling and subsequently dropped the EOS activation ring between the seat and the console. The pilot advisor had significant difficulty retrieving the dropped EOS activation ring while wearing cold weather gloves. The pilot advisor could not visually locate the EOS activation ring without twisting his torso due to the bulky flight gear and the EOS activation ring's design, size and location. In addition, the NVGs impacted the canopy when the pilot advisor moved his head to visually locate the EOS activation ring. Therefore, I find, by a preponderance of the evidence, personal equipment interference and controls/switches were substantially contributing factors in the mishap.

Additionally, during ground simulations, the AIB observed that the pilot advisor made inadvertent control stick and pedal movements while twisting his torso to visually locate the EOS activation ring. At 19:42:53L, the MP began a 15-second series of stick and pedal movements, which resulted in an unusual attitude. The movements reversed the MA's turn direction while rolling through inverted flight, increased the ND attitude, and accelerated the descent rate to greater than 1,000 feet per second (fps). The roll rate and change in gravitational force were above the minimally detectable threshold and should have been perceived by the MP. The AIB determined these inputs to be inadvertent because they do not reflect expected or intentional inputs consistent with basic aircraft control. Therefore, I find, by a preponderance of the evidence, inadvertent operation was a substantially contributing factor in the mishap.

Due to the aforementioned substantially contributing factors, the AIB determined the MP initially channelized his attention on restoring oxygen flow while attempting to manually activate the EOS. Channelized attention is a factor when an individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. When the airflow stopped to the MP's oxygen mask, the MP tightly focused his attention inside the cockpit and that led to the exclusion of maintaining aircraft control and situational awareness. Therefore, I find, by clear and convincing evidence, that channelized attention was a cause in the mishap.

The MP's channelized attention led to a breakdown in visual scan. Breakdown in visual scan is a factor when an individual fails to effectively execute learned/practiced internal or external visual scan patterns. The breakdown can lead to an unsafe situation. In a single-seat aircraft, the pilot is solely responsible for maintaining aircraft control while managing other cockpit tasks. A continuous cross-check of in-flight parameters via cockpit instruments or outside references is essential. Had the MP maintained an effective visual scan of the cockpit instruments or looked recognized the change in aircraft orientation and made corrective flight control inputs. Since the MP did not take corrective action until below minimum dive recovery altitude, I find, by clear and convincing evidence, that breakdown in visual scan was a cause in the mishap.

Channelized attention and breakdown in visual scan led to unrecognized spatial disorientation. The AIB determined the MP lost cognitive awareness of the MA's location and orientation relative to the ground, and did not make proper control inputs because the need was unknown. Both the inadvertent flight control inputs and resulting unusual attitude went unnoticed by the MP. The MA's increased ND attitude accelerated the descent rate to greater than 1,000 fps and shortened the amount of time available to recover the aircraft. At the completion of the inadvertent flight control inputs, the MA was 19 seconds from impact. Since the MP did not take corrective actions until approximately three seconds prior to impact, it is evident that he had unrecognized spatial disorientation for a period of time. By the time the MP recognized the unusual attitude and applied dive recovery flight control inputs, the MA had transitioned below the minimum safe recovery altitude and his final efforts to recover came too late. Therefore, I find, by clear and convincing evidence, unrecognized spatial disorientation was a cause in the mishap.

CONCLUSION

By clear and convincing evidence, I find the cause of the mishap was the MP's failure to recognize and initiate a timely dive recovery due to channelized attention, breakdown of visual scan and unrecognized spatial disorientation. Further, I find by a preponderance of the evidence that organizational training issues, personal equipment interference, controls and switches, and inadvertent operation were factors that substantially contributed to the mishap.

JUN -7 2013

JAMES S. BROWNE, Brig Gen, USAF
President, Accident Investigation Board

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.