SPECIAL REPORT

AIRBORNE IMAGING 2011

ELECTRO-OPTICAL INFRA-RED

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Multi-Spectral Targeting Systems

Raytheon Multi-Spectral Targeting Systems deliver superior ISR and targeting capabilities at an unbeatable value. With more than one million operational flight hours to date, Raytheon's family of MTS sensors equip manned and unmanned aircraft with combat-proven mission capabilities. Interchangeable, survivable and made adaptable for any platform, MTS provides superior detecting, ranging, and tracking for military, national and civil missions worldwide.

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FOREWORD

Quality intelligence, surveillance and reconnaissance (ISR) has unquestionably become a prized capability in the current counterinsurgency environment in Afghanistan and Iraq, where the adversary cam move quickly and in small numbers, blend in with the local population, and adjust tactics quickly to exploit US weaknesses.

The former head of US Air Force intelligence, Lieutenant General David Deptula, put it succinctly in a Winter 2010 Air and Space Power Journal article when he and a colleague wrote "amateurs do continue to talk about strategy, but professionals increasingly talk about information — how to get it, use it, and keep getting it, given the speed, complexity, and character of the challenges faced by our forces abroad and our domestic security organizations at home."

This demand for high-fidelity ISR at the strategic, operational and tactical levels has driven an unprecedented revolution in sensor technology. Since the 2002 US-led invasion of Iraq, defence contractors in America and abroad have scrambled to produce increasingly sophisticated airborne ISR payloads that can operate multiple cameras, use lasers to designate targets, and transmit imagery and coordinates to ground forces in near real-time.

Strapped to manned aircraft or aerial drones, these multi-spectral sensors operate in multiple modes – usually with both day (electro-optical camera) and night (infrared camera) capability – to provide ground forces critical, time-sensitive information about the insurgent hiding around the corner or entering a town by vehicle. Both sensor types are typically equipped with high-magnification optical lenses that may provide zoom capability. They may also have laser rangefinders or designator/rangefinders to help identify targets.

Demand for these airborne, multi-spectral sensors skyrocketed after the 2002 invasion of Afghanistan. The head of Raytheon's surveillance targeting systems product line, Andy Bonnot, recalls that US military demand for airborne ISR was so urgent that the company found itself filling orders in just 90 days.

Since then, US and coalition forces' requirements have only grown, with Raytheon, for example, delivering over 100 ISR systems by the summer of 2005, and five years later, in 2010, hitting the one thousand mark.

These airborne, multi-spectral sensors are frequently packaged into a turret, which is a mounting for sensor payloads that is gyro-stabilised to ensure the delivery of clear images despite aircraft vibrations. These turrets can be mounted on unmanned aerial vehicles, helicopters, fixed wing aircraft and even aerostats.

Overtime, as sensors have decreased in size and increased in resolution, more and more can be packed into one turret. Wide Area Airborne Surveillance (WAAS) systems, which are now being developed by both the US Air Force and US Army, can have as many as nine sensors packaged on the turret. Sierra Nevada Corporations' Gorgon Stare payload, for example, houses five EO cameras and four IR cameras.

Turret stabilisation technology also has been refined in recent years, with the most common configuration becoming a four-axis set of two gyro-stabilised gimbals.

In addition, image resolution improved with the advent of high-definition (HD) TV. Both electro-optical (Charged Coupled Device TV) and infrared (thermal imaging) cameras have benefitted from HD technology, which increases the number of pixels in a sensor's array to improve image resolution. In particular, focal plane arrays have evolved from a 320 x 240 format to 640 x 480 pixels, and now, HD array formats of 1,920 × 1,080 pixels, as is the case with the miniature 1080p HD camera in L-3 Wescam's MX-15HDI sensor turret.

Thermal sensors in particular have undergone some significant improvements in recent years, both in terms of the materials from which they are made and the process by which they operate. Most sensor turrets incorporate staring focal plane array (FPA) thermal imagers, which often operate in either the mid-wave infrared (MWIR 3-5 μm) or long-wave infrared (LWIR - 8-12 μm) spectral ranges, depending on the mission set.

One common thermal imager material is mercury cadmium telluride (MCT), which requires cryogenic cooling to enhance its thermal sensitivity. Cooled systems have been around a long time, but uncooled sensors have also made strides in recent years. The advantage of uncooled infrared detectors is that they are lighter and may have a smaller logistics burden, since they don't require the tubes, wires, and other components necessary for cooling. The trade-off is that they may

have a reduced thermal sensitivity without cooling, and therefore need more sensitive optics.

Airborne multi-spectral sensors also benefit from ever-improving image processing software. Various software algorithms can be employed to enhance image resolution. GPS/INS systems can be integrated with the sensors to allow for geo-location tagging of images, meaning one can reference the image on a local map. The GPS/INS systems also can be used to help sensors continuously track targets.

All of this imagery can be transferred via data link to operators with access to displays available at ground stations, inside ships, at air operations centres, and distributed ground stations, and on tactical hand-held systems like the Remotely Operated Video Enhanced Receiver (ROVER) and the One System Remote Video Terminal (OSRVT).

Some of the most common airborne multi-spectral sensors in theatre today are Raytheon's Multi-Spectral Targeting Systems (MTS) series. The Navy uses the MTS-A, designated the AN/AAS-44C, onboard its HH/MH-60 Seahawk helicopters. The US Air Force uses the MTS-A, designated the AN/AAS-52, on its MQ-1 Predator unmanned aircraft, as well as the MTS-B, designated AN/DAS-1 on its MQ-9 Reaper aerial drone. Also part of the MTS family is the AN/ZSQ-2 (V) turret used on helicopters of the US Special Operations Command.

Another widely used sensor is L-3 Wescam's MX-15, a mid-size sensor with a 394 mm diameter, along with the larger MX-20 (530 mm diameter) and the smaller MX-10 (260 mm diameter). The MX-15Di is equipped onboard the USAF's MC-12W Project Liberty fixed wing aircraft.

As the quality and availability of airborne, multispectral sensors continues to improve, the amount of imagery available to warfighters is also growing. While the demand for ISR appears to be insatiable on the battlefield, the warfighters' ability to digest all the information is limited by the manpower available to process it all.

As a result, both American defence contractors and the US military are paying more attention to improving data management through autonomous systems. To reduce information overload, companies are seeking to increase the autonomy of airborne, multi-spectral sensors. This concept allows developing technology that can select the most useful "change information" and send it down to the operator, rather than sending down hours of video in which nothing of much use or interest is occurring. For example, a UAV equipped with a multispectral sensor to monitoring a village would not send down hours of video feed, but instead would be programmed to send down only the most relevant imagery, such as a new vehicle entering the village.

This special report attempts to highlight some of the airborne, multi-spectral sensors having a major impact battlefield ISR today. With new sensors coming on the market at a rapid rate, this report is not intended to be comprehensive, but rather to provide a general overview. The sensors described here are multi-spectral, turreted, airborne, dedicated to the ISR mission, and are medium to large in terms of size. Small and miniature airborne multi-spectral sensors, which are proliferating rapidly, were omitted from this report and are prevalent enough to be revisited in an entirely separate special report dedicated only to them.

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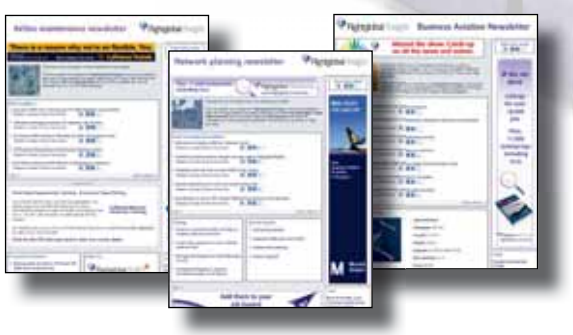

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NORTH AMERICA

DRS

GS410-LD Stabilised Multisensor

The GRS410-LD features Forward Looking Infrared (FLIR), zoom colour TV, laser pointer, laser range finder, and optional laser designator, integrated with an automatic video tracker.

GS410-LD STABILISED MULTISENSOR	
Payload weight	less than 20.4 kg (45 lb)
Dimensions	39.9 cm height x 26.2 cm diameter
Field of view	Infrared: 30°; 8.6°; 2.2° horizontal TV: continuous 58° to 1.7° horizontal
Stabilisation applications	4 axis stabilisation

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Mast Mounted Sight (MMS)

The MMS is an electro-optical sensor system that consists of three subsystems, including the turret, the control/display panel and the onboard electronics. Onboard sensors include a CCD television, thermal imaging sensor (TIS), laser-range finder/designator, and an automatic Optical Boresight Tool. A digital scan converter improves the TIS image and provides electronic zoom capability.

Over 420 systems were delivered to the US Army for the OH-58D Kiowa Warrior armed scout helicopter from 1990. Taiwan purchased 51 MMS sets for OH-58D use.

MAST MOUNTED SIGHT (MMS)	
Platform	OH-58D Kiowa Warrior
Payload weight	113.4 kg
Dimensions	64.77 cm diameter
Field of view	CCD television camera: 2° NFoV; 8° WFoV Thermal Imaging Sensor: 2.8° NFoV; 10° WFoV
Range	CCD television camera Spectral range: 0.65 to 0.9 μm Thermal Imaging Sensor Spectral range: 8 to 12 μm Laser Range Finder Wavelength: 1.06 μm
Stabilisation applications	2-axis, <20 μrad jitter

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FLIR

AN/AAQ-22E BRITE Star II and BRITE Star DP

The BRITE STAR II consists of sensors added to the AN/AAQ-22 SAFIRE/Star SAFIRE family of turrets. The surveillance and targeting system combines color optical imagery (a three-field of view, high-resolution, 3 chip color daylight camera with monochrome mode) with a five field-of-view large format thermal imager. It also carries a diode-pumped laser designator/range finder and laser pointer.

The system is compatible with US and NATO laser-guided munitions, including AGM-114 Hellfire missiles.

The BRITE Star II is the sensor used on the Northrop Grumman MQ-8B Fire Scout Vertical Unmanned Aircraft System (VUAS). The unmanned helicopter flew for the first time from the US Navy's Littoral combat Ship (LCS) on 18 November. The US Marine Corps are equipping UH-1 Iroquois (Huey) with BRITE Star II, as well as their successor airframe, the UH-1Y Venom scout and utility helicopter.

The BRITE Star DP is an export version, and it is essentially the same sensor fit as the BRITE Star II, but with less capability in some areas including magnification and range. It was designed for an undisclosed international customer.

AN/AAQ-22E BRITE STAR II	
Platform	Northrop Grumman MQ-8B Fire Scout
Payload weight	Turrett Flir Unit (TFU) weight: 120 lbs (54.4 kg) 125 lbs (56.7 kg) with boresight module Control Electronic Unit: (CEU): 24 lbs (10.9 kg)
Dimensions	TFU: 16.2 in x 19.3 in (410 mm x 490 mm) CEU: 10.0 in x 7.5 in x12.5 in (254 mm x 191 mm x 318 mm)
Field of view	30° to 0.31° in five stages
Range	3-5 μm Spectral Range of Thermal Imager: 3 to 5 μm Range of Laser RangeFinder: 20 km (±5 m)
Stabilisation applications	4-axis gimbal

© FLIR

BRITE STAR DP

The BRITE Star DP is an export version, and it is essentially the same sensor fit as the BRITE Star II, but with less capability in some areas including magnification and range performance.

BRITE STAR DP	
Payload weight	TFU: 120 lbs (54.4 kg) 125 lbs (56.7 kg) with boresight module CEU: 24 lbs (10.9 kg)
Dimensions	TFU: 16.2 in x 19.3 in (410 mm x 490 mm) CEU: 10.0 in x 7.5 in x 12.5 in (254 mm x 191 mm x 318 mm)
Field of view	Thermal Imager: 30° to 0.45° Daylight camera: matched to thermal imager field of views
Range	Spectral Range of Thermal Imager: 3 to 5 μm Range of Laser RangeFinder: 20 km (±5 m)
Stabilisation applications	4-axis gimbal

STAR SAFIRE

First fielded around six years ago by television news channels and the film industry, digital high-definition imaging systems are increasingly standard kit for military buyers.

FLIR Systems' standard-bearer in this fast-growing market segment is its Star Safire HD system. When unveiled at the Paris Air Show in 2005, FLIR described the latest member of the Star Safire portfolio as the first all digital HD payload "from the detector to connector". That event also saw the announcement of the Star Safire HD's – the US Army, which mounts the camera on a tethered aerostat as a surveillance system for bases in Afghanistan and Iraq.

Contained within a 15in turret, the stabilised HD system offers thermal, colour and image intensified cameras, three lasers and an inertial measurement unit.

The product has been updated since 2005 to increase the range, performance and "pixels on target" of the infrared imager's focal-plane detectors.

STAR SAFIRE	
Payload weight	less than 45kg
Dimensions	380mm x 475mm (single LRU)
Field of view	Colour high definition: 29º to 0.25º Colour low light high definition: 55º to 1.5º Short wave infrared: 28º to 0.25º Thermal imager: 30º to 0.25º
Stabilisation applications	6-axis

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MULTI 800

The Multi 800 provides daylight, medium-wavelength (3 - 5 m) and long-wavelength (8 - 12 m) infrared imaging, as well as laser range finding, laser pointing and marking, and a Class 3b laser. The system is designed for lightweight unmanned aerial vehicles, piloted vehicles, and other small moving platforms such as balloons, kites, and boats.


© Hood Technology

MULTI 800	
Platform	US Navy Insitu Integrator
Payload weight	5,550 gm
Dimensions	25.4 cm diameter
Field of view	2.50 and 100 mid-wave IR 240 long-wave IR 1.70 - 560 electro-optical
Range	Thermal imaging: 3 - 5 m mid-wave IR 8 - 12 m long-wave IR 400 - 900 m electro-optical Laser Marker: 830 nm Laser Range finder: 3 km

L-3

L-3 Wescam MX-10 Sensor Turret

The MX-10 sensor turret, introduced at the 2009 Paris Air Show, is the smaller cousin of L-3's MX-15 and MX-20 sensor families. It offers a total of six payloads including a thermal imager; a two-megapixel daylight continuous zoom colour HD TV camera;a Low-Light continuous zoom electron-multiplied CCD TV camera; a laser rangefinder; a laser illuminator, and a laser pointer.

The system began flight trials onboard the AS 355 Ecureuil II helicopter in May 2009 and was also demonstrated at HeliTech international in September 2009.

L-3 WESCAM MX-10 SENSOR TURRET	
Platform	The system is relatively new, and its small size is geared toward airframes with lower ground clearance
Payload weight	37 lb turret
Dimensions	14 in (35 cm) turret height for lower ground clearance Gimbal (diam × h): 26 × 35.5 cm Hand controller (w × l × d): 10.8 × 22.8 ×
Range	Thermal Imager spectral range: 3 to 5 μm
Stabilisation applications	Four-axis stabilized gimbal and hand controller


© L-3

MX-15 (AN/AAQ-35, AN/AAQ-38), and MX-15i/D/Di/True HD sensor variants

The MX-15, designated the AN/AAQ-35 and AN/AAQ-38 in the United States, is a family of mid-size sensor turrets. The system features long-range capability and be equipped with up to six sensors, allowing versatility across a range of platforms, including fixed wing, rotary wing, unmanned aerial vehicles (UAV's) and aerostats.

© L-3

The MX-15 supports 1 to 6 payload sensors. Standard payloads include a high-magnification thermal imager with a colour 1-Charged Coupled Device (CCD) camera with zoom lens.

Other optional sensors include:

- a second CCD camera (colour or monochrome);
- laser rangefinder;
- laser illuminator:
- laser pointer.

Evolved from the MX-15, the MX-15i includes some new features:

- An integrated microcontroller(MCU), which allows as much as a 50 lb weight reduction by moving what were once considered external control electronics to the turret top
- A Charge-Multiplied Charge-Coupled Device (CMCCD) Night Spotter camera, which enables offers long-range identification in low light conditions.
- A Laser Illuminated Night Spotter, which allows long-range identification in total darkness.
- An improved thermal imager, featuring a 20 μm-pitch IR detector array that offers a 20 percent increase in infrared range, magnification and resolution
- MX-GEO, Gen -3, a package consisting of GEO-Scan, Automated Video/GEO-Tracking, Integrated GEO-Tracking and Adaptive-GEO, each of which aid in maximising the accuracy of target location.

Further developments have led to the MX-15Di (Designator), which features improvements in range, resolution and magnification that L-3 claims have led to the development of the "longest EO/IR target identification range in the industry."

Similar to the MX-15i, the MX-15DI features an MCU located on top of the turret instead of externally. The payload supports up to six sensors, including:

- Colour daylight camera with zoom lens
- Monochrome daylight camera with spotter lens
- Thermal imager with high magnification 4-step zoom
- Laser designator
- Laser range finder
- Laser target illuminator

The MX-15 True HD is a version of the MX-15i that features a miniature camera with 1080p imaging resolution to provide high definition imagery. The sensor also features Enhanced Local Area Processing (ELAP), which enables real-time image enhancement; this high-speed processing of images allows for increased standoff range, improved feature recognition and maximum haze penetration, according to L-3.

Like the MX-15i and MX-15Di, the MX-15 True HD hosts its electronics control unit on top of the turret instead of externally to reduce weight.

L-3 MX-15	
Payload weight	42.7 kg
Dimensions	394 x 470 mm
Field of view	High Magnification Thermal Imager: NTSC: 31.7 to 0.43° (in four stages) PAL (large format): 31.8°, 6.51°, 1.30°, 0.52° PAL (small format): PAL 19.4°, 3.91°, 0.78°, 0.52° Color daylight TV with zoom lens: 27.4 to 1.4° FoV with optional ×19 lens with ×2 extender: 30.3 to 0.86° TV Camera with spotter lens (optional): 0.29° or 0.39°
Range	High Magnification Thermal Imager spectral range: 3 to 5 μm Laser range finder: 10 km (20 km range gate)
Stabilisation applications	four-axis active gyro-stabilisation, plus six-access passive isolation vibration stabilization. All MX-series turrets feature an Inertial Measurement Unit (IMU) mounted on the inner gimbal with the payload. The MX-GEO package also helps with stabilization, providing GEO-pointing, GEO-steering, GEO-focus, auto-tracker and moving map functions are all available.

MX-20 (AN/ASX-4)/MX-20HD

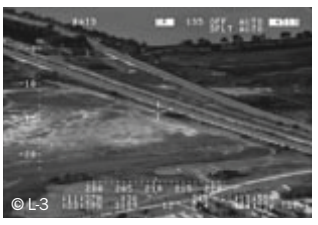
The MX-20 is designed to provide long-range stand-off surveillance and identification, being gyro-stabilised and having high magnification optics. Initially configured to accommodate up to six sensor systems, since September 2005 a seventh has been possible.

L-3 has also developed a high definition verison of the turret, known as MX-20 True HD, which is capable of providing 1080p imaging resolution

- a thermal imager, with high magnification 4-step zoom;
- colour daylight CCD camera with zoom lens;
- colour (or monochrome) daylight camera with 4-step spotter lens;
- night camera, with 4-step spotter lens;
- laser rangefinder; and
- two choices of laser illuminator/pointer, claimed by the company as being “able to see clearer and further than any system in its class”.

© L-3

MX-20	
Platform	Deployed on the US Navy's P-3C Orion ; US Coast Guard'sHC-130H Hercules(with the designation An/ASX-4); Canada's CP-140 Aurora; and US Army Persistent Threat Detection System aerostat The MX-20 is the chosen turret for Lockheed Martin's AN/AAQ-30 Hawkeye target sight system, which is for the US Marine Corps' AH-1Z SuperCobra helicopter upgrade. The MX-20 also has been selected to equip the Royal New Zealand Air Force fleet of five P-3K Orions, as part of the Project Guardian upgrade. The MX-20 is also part of the sensor package for Selex Galileo's Airborne Tactical Observation and Surveillance (ATOS) system, which is equipped on Italian Ministry of Finance ATR-42 MP Surveyor maritime patrol aircraft. Norway ordered eight MX-20 systems for its P-3 Orion fleet in April 2006. Australia announced that the ATOS-derived system had been selected to equip 10 Dash 8 Q200 aircraft and two helicopters (Bell 206LR and 412EP) in February 2007. Boeing selected the MX-20HD for the US Navy's P-8A Poseidon aircraft in March 2008. L-3 announced also has a contract with the US Air force for an undisclosed number of MX-20D with HD sensors to be supplied to an unnamed customer. L-3 announced in September 2010 a contract with Quantum Research International to provide four imaging and targeting systems for the US Army's Long Endurance Multi-intelligence Vehicle (LEMV) L-3 Wescam will supply two MX-20D (plus two MX-15HDi) sensor turrets to equip the LEMV.
Weight	84.1 kg
Dimensions	53 × 67 cm
Field of view	High magnification thermal imager: 18.2° to 0.24° in four stages (720p and 1,080p) Colour daylight TV with zoom lens (standard) Fields-of-view (option A): 41.3° to 2.2° (7200p); 44° to 3.2° (1,080p) Fields-of-view (option B): 21.3° to 1.83° (7200p); 18.2° to 2.75° (1,080p) TV with step spotter lens (optional) 0.115° to 0.61° (720p); 0.17° to 0.92° (1,080p) in 4-steps MX-Day/Night Spotter{TM} with dual-channel step-spotter (requires Colour HD camera above) 0.14° to 0.73° in 4-steps (720p and 1,080p)
Range	High Magnification Thermal Imager: 3 to 5 μm Laser range finder: 30 km (50 km range gate)
Stabilisation applications	5-axis gyro-stabilisation 6-axis vibration isolation



Lockheed Martin

AN/AAQ-30 Target Site System (TSS)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Lockheed Martin's TSS is the multi-sensor electro-optical/infrared (EO/IR) fire control system for the U.S. Marine Corps AH-1Z Cobra attack helicopter. It features a large-aperture (8.55 inches) midwave forward-looking infrared (FLIR) sensor, colour TV, laser designator/rangefinder (with eyesafe mode), and an on-gimbal inertial measurement unit integrated into a turret.

The turret mounts to the nose of the aircraft via the Lockheed Martin-developed aircraft interface structure.

TSS provides the capability to identify and laser-designate targets at "maximum weapon range," according to Lockheed Martin.

AN/AAQ-30 TARGET SITE SYSTEM (TSS)	
Platform	US Marine Corps AH-1Z Cobra attack helicopter.
Payload weight	Turret: 83 kg Electronics unit: 33 kg
Dimensions	520 mm diameter
Field of view	Wide: 21.7° × 16.3° Medium: 4.4° × 3.3° Narrow: 0.88° × 0.66° Very narrow: 0.59° × 0.44°
Stabilisation applications	Gimbal stabilized to <15 microradians, includes on-gimbal inertial measurement unit for reduced image blur due to jitter and precise line pointing, target geo-location, and multi-target tracking


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AN/AAS-52 Multi-Spectral Targeting System MTS-A

The AN/AAS-52 MTS-A incorporates electro-optical, infrared (EO/IR) and laser-ranging capabilities. The system provides long-range surveillance, target acquisition, tracking, range-finding and laser designation for the AGM-114 Hellfire missile and for all tri-service and NATO laser-guided munitions. The system was flown on the MQ-1 Predator in the late 1990's in support of the US military's involvement in Kosovo, and US military orders exploded after the 9/11 attacks, when the USAF began an aggressive effort to arm MQ-1 Predator aircraft with Hellfire missiles, according to Andy Bonnot, Raytheon's product line director for Surveillance & Targeting Systems. High definition (HD) capability is available if requested, according to Raytheon.


© Raytheon

AN/AAS-52 MULTI-SPECTRAL TARGETING SYSTEM MTS-A	
Platform	Rotary wing (known as AN/AAS -44C (V) when equipped on the US Navy MH-60R and MH-60S helicopters) and unmanned air vehicles including the MQ-1 Predator. Raytheon says the MTS-A is also suitable for fixed wing applications. US Special Operations Command MH-47 and MH-60 helicopters are equipped with a sensor evolved from the MTS-A and MTS-B that fits on the nose of the helicopter, known as the AN-ZSQ-2.
Payload weight	Weapons Replaceable Assembly 1 (WRA-1): 130 lb WRA-2: 25 lb
Dimensions	WRA: 1: 18 in diameter WRA 2: 1/2 ATR, 14.4 (L) x 4.9 (W) x 7.6 (H) inches (for 28 Vdc operation)
Field of view	Wide: 34° x 45° Medium-wide: 17° x 22° Medium: 5.7° x 7.6° Medium-narrow: 2.8° x 3.7° Narrow: 1.2° x 1.6° (IR and TV) Ultra-narrow: 0.6° x 0.8° (IR) Ultra-narrow: 0.21° x 0.27° (TV)
Stabilisation applications	Six-axis stabilized mount

AN/DAS-1 Multi-Spectral Targeting System MTS-B

Similar to Raytheon's MTS-A predecessor, the MTS-B provides electro-optical, infrared and laser detecting, ranging and tracking for the AGM-114 Hellfire and all tri-service/NATO laser-guided munitions. However it is bigger than the MTS-A, and it was developed and produced specifically for high-altitude applications onboard the Air Force's larger MQ-9 Reaper, which can be armed with the AGM-114 Hellfire missile.

"With the B's you can fly higher, you can image from farther away, and you don't have to be so close," said Andy Bonnot, Raytheon's product line director for Surveillance & Targeting Systems. The sensor has also been selected for incorporation onboard the US Navy's MQ-4C Broad Area Maritime Surveillance (BAMS) unmanned aircraft fleet. High definition (HD) is also available, according to Raytheon.


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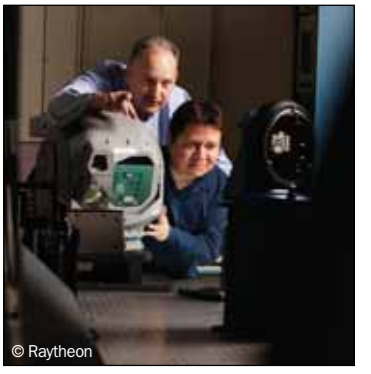
AN/DAS-1 MULTI-SPECTRAL TARGETING SYSTEM MTS-B	
Platform	Unmanned aerial vehicles including the MQ-9 Reaper and the MQ-4C, the US Navy's Broad Area Maritime Surveillance (BAMS) Raytheon says it is also suitable for helicopter and fixed-wing aircraft applications.
Payload weight	Weapons Replaceable Assembly 1 (WRA-1): 230 lb WRA-2: 25 lb
Dimensions	WRA-1: 22 in. diameter WRA-2: ½ ATR, 14.4 (L) x 4.9 (W) x 7.6 (H) inches

AN/AAS-53 Common Sensor Payload (CSP)

The US Army selected Raytheon to provide the Common Sensor Payload for multiple manned and unmanned aircraft in November 2007. The sensor builds on the MTS-A and MTS-B technology, but Raytheon has not specified exactly what capabilities it will entail, in part because the sensor can be tailored to meet the individual needs of various platforms. Company literature describes several sensor options, however, including electro-optical/infrared (EO/IR) capability and laser detecting, ranging and tracking. In particular, the literature specifies the following options:


© Raytheon

- Large-format mid-wavelength infrared (MWIR) and multiple-wavelength infrared sensors for night-time viewing
- Daytime color TV sensors - for surveillance with various lens options, as well as Image-intensified (I2) TV sensors;
- NIR TV sensors
- Dual-band (operational and eye-safe) laser rangefinders;
- Laser spot trackers/designators; and
- Laser pointers.
- Laser and eyesafe rangefinders
- Autotrackers
- Forward-looking infrared sensors (FLIR)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The CSP was originally intended for the army's now-cancelled ARH-70A Armed Reconnaissance Helicopter (ARH) and the Extended Range Multi-Purpose (ERMP) unmanned aircraft, the MQ-1C Sky Warrior (re-named Gray Eagle by the US Army in August 2010).

The army is performing a Cockpit and Sensor Upgrade Program (CASUP) on the OH-58D Kiowa Warrior armed scout helicopter that will include replacing the current Mast-Mounted Sight with the CSP.

Stabilization Applications Sensor system will be packaged in a multi-axis stabilised gimbal turret


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AN/AAS-53 COMMON SENSOR PAYLOAD (CSP)	
Platform	Scheduled for integration on the MQ-1C and the OH-58F
Payload weight	161 pounds

Airborne Vision Enhanced System (AVES)

Raytheon's Airborne Vision Enhanced System (AVES) is an electro-optical/infrared (EO/IR) system with laser tracking that has been developed and produced for international customers seeking both overland and maritime surveillance capabilities. The sensor system is part of the mission suite onboard the Shadow R Mk 1, a UK Royal Air Force fixed wing, manned intelligence, surveillance and reconnaissance (ISR) aircraft based on the King Air 350CER.

© Raytheon

AIRBORNE VISION ENHANCED SYSTEM (AVES)	
Platform	Shadow R Mk 1
Payload weight	WRA-1: 130 lbs WRA-2: 35 lbs
Dimensions	WRA-1: 18 in. WRA-2: 2 ATR, 16.5 in. (L) x 13.5 in. (W) x 9.3 in. (H) (for 28 Vdc operation)
Field of view	Wide: 34°-45° Medium-wide: 1° x 22° Medium: 5.7° x 7.6° Narrow: 1.2° x 1.6° (IR and TV) Ultra-narrow: 0.6° x 0.8° (IR) Ultra-narrow: 0.21° x 0.27° (TV)

Advanced Airborne Optical Sensor System (AAOSS)

This electro-optical infrared (EO/IR) sensor is designed to provide long-range surveillance, high altitude target acquisition and tracking of ballistic missiles. The US Missile Defense Agency is using it in experimentation with forward-deployed advanced infrared sensors for missile defense applications.

ADVANCED AIRBORNE OPTICAL SENSOR SYSTEM (AAOSS)	
Platform	MQ-9 Reaper
Field of view	Wide: 34-45 Medium-wide: 1° x 22° Medium: 5.7° x 7.6° Narrow: 1.2° x 1.6° (IR and TV) Ultra-narrow: 0.6° x 0.8° (IR) Ultra-narrow: 0.21° x 0.27° (TV)

Sierra Nevada Corporation

Gorgon Stare

Gorgon Stare is being developed on behalf of the US Air Force (USAF) for wide area airborne surveillance (WAAS) on-board the MQ-9 Reaper unmanned aerial system (UAS).

Designed to be pod-mounted onboard an MQ-9 Reaper, Gorgon Stare consists of an ITT-manufactured turret that can carry various sensors to provide city-wide views. These city-wide views also can be "chipped out" into as many as 10 spot images that can be transmitted to ground forces operating hand-held OSRVT or ROVER systems. Imagery can also be transmitted to Gorgon Stare Ground Stations via datalink.

The sensor package for increment one of Gorgon Stare consists of five day-light black and white EO cameras and four infrared cameras.

Gorgon Stare also makes use of a Gorgon Stare Ground Station for image processing.

Increment two of Gorgon Stare is expected to include a new type of EO sensor, developed by the Defense Advanced Research Projects Agency (DARPA) and known as Autonomous Real-time Ground Ubiquitous Surveillance (ARGUS-IS).

Flight tests of the BAE Systems-manufactured ARGUS-IS were conducted on-board a US Army Sikorsky UH-60 Black Hawk helicopter and concluded in October 2009.

The addition of ARGUS-IS is expected to offer imagery resolution that is twice as good as that in increment one.

GORGON STARE	
Platform	MQ-9 Reaper
Payload weight	About 1000 pounds (454 kg)

EUROPE/ISRAEL

Controp

DSP-1

The DSP-1 consists of a four-gimbal, gyro-stabilised turret that includes two sensors: a high-resolution colour CCD daylight TV camera (or a 3-CCD TV as an option) with ×20 zoom, as well as one of the company's Fox Gen 3 thermal cameras. Choices include either the Fox-720 with an InSb 320 × 256 FPA and a ×22.5 zoom lens or the Fox-600 with a high-resolution 640 × 512 FPA.

DSP-1	
Platform	The DSP-1 is marketed toward UAV's, helicopters, fixed wing aircraft, and aerostats.
Payload weight	22.5 kg turret; Payload Electronic Box: 3.5 kg
Dimensions	330X483 mm
Field of view	Fox-720 thermal imager: wide 27.0° × 20.6°; narrow 0.76° × 0.57° (with 320 x 256 FPA) Daylight TV Camera: wide: 13.6° x 10.2° ; narrow 0.7° x 0.52°
Range	Fox-720 thermal imager spectral range: 3 to 5 μm
Stabilisation applications	4 – gimbal gyro-stabilised turret

LDP

The LDP System is a compact Day/Night/Designator observation system especially configured for use on UAVs, military helicopters and marine patrol boats.

LDP	
Platform	The LPD is optimised for UAV and helicopter applications
Payload weight	Turret: 32 kg; Payload Electronic Box: 3.5 kg
Dimensions	354 mm
Field of view	Fox-720 thermal imager : wide 27.0 × 20.6°; narrow 0.76 × 0.57° (with 320 X 256 FPA) Daylight TV Camera: narrow 0.70° × 0.52°; wide: 13.6° × 10.2° Optional 3 CCD TV camera: narrow: 0.90° × 0.68°; wide: 18.0° × 13.5°
Range	Fox-720 thermal imager spectral range: 3 to 5 μm

Elbit

Compact Multi-Purpose Advanced Stabilised System (CoMPASS)

The CoMPASS family of systems is a highly stabilized, multi-sensor electro-optical payload. It features a thermal imager, colour TV camera, laser rangefinder/designator and laser target illuminator. The latest model, known as the CoMPASS IV, is lighter than the previous version. An all-digital version known as DCoMPASS is also available, as well as two small diameter version known as Mini-CoMPASS and Micro-CoMPASS.


© Elbit

The CoMPASS system can be used for the following missions:

- Automatic target tracking
- Dual color target designation
- Line of Sight (LOS) positioning for fire control applications
- Navigation capabilities for target gathering and geolocation

See the separate entry for a description of DCoMPASS.

The Mini-CoMPASS has a 305 mm (12 in) diameter, and the Micro-CoMPASS has just a 203 mm (8 in) diameter.

COMPASS	
Platform	Designed for fixed wing, helicopters, UAV's.
Payload weight	38 kg with laser designator
Dimensions	38 cm (15 in) diameter
Field of view	Thermal Imager: 0.61° × 0.46° (narrow); 2° × 1.5° (medium); 13.7° × 10.2° (wide) Colour TV: 0.7° × 0.52° (narrow); 13.7° × 10.2° with × 2° (wide)
Range	Thermal Imager (spectral) : 3 to 5 μm Colour TV (spectral) : 450 to 750 nm Laser target illuminator (spectral) : 830 nm Range: 10 km

Digital Compact Multi-Purpose Advanced Stabilised System (DCoMPASS)

A variant of CoMPASS, DCoMPASS has a full digital architecture and can carry six sensors, including a gimbal-mounted inertial measurement unit that allows for highly accurate navigation, target location and geo-location. Other sensors include:


© Elbit

- Forward Looking Infrared (FLIR) Thermal imager
- Large format Charged Couple Device (CCD) colour tv camera
- Laser target illuminator
- Laser rangefinder
- Laser target designator

In December 2005, DCoMPASS was selected for the UK's WK450 Watchkeeper UAV , a variant of the Elbit Hermes 450 UAV.

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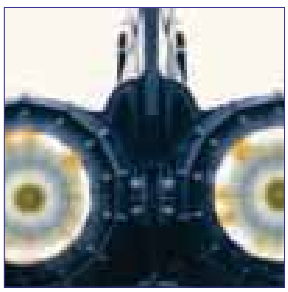

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DCOMPASS	
Platform	UK's WK450 Watchkeeper UAV
Payload weight	33 to 38 kg
Dimensions	38 cm (15 in) diameter
Field of view	Thermal Imager (2 Sensor Model Options) Flir A-Topaz: 24° × 18° (wide); continuous (medium); 0.8° × 0.6° (narrow) Flir B-Lotus: 13° × 7° (wide); 2.0° × 1.5° (medium); 0.61° × 0.46° (narrow); Color TV: 0.59° x 0.44° (narrow) 21.25° x 16° (wide)
Range	Thermal Imager Spectral Range: 3-5 µm Laser Range finder: 20 km

Israel Aerospace Industries (IAI)/Tamam

Multimission Optronic Stabilised Payload (MOSP)


© IAI

IAI's Tamam division produces the MOSP family, and its helicopter-specific derivative, HMOSP, with thermal, and TV sensors and laser rangefinder/pointer.

Israel Aerospace Industries' (IAI's) Tamam division produces a Multimission Optronic Stabilised Payload (MOSP) and a helicopter-specific derivative HMOSP, with the three main thermal, TV and laser sensors; while the latest application for the POP-200 turret has been on IAI's Harop loitering, precision-guided munition.

Specifications below are for the generic for the family of MOSP sensors.

MULTIMISSION OPTRONIC STABILISED PAYLOAD (MOSP)	
Platform	US Army's Northrop Grumman-manufactured MQ-5A Hunter UAV; Finnish Army IAi/ Oerlikon/RUAG Ranger UAV, and other unspecified customers that use it for fixed wing, rotary wing, manned and unmanned aircraft, and also ships and ground vehicles.
Payload weight	30-35 kg (configuration-dependent)
Dimensions	350 mm diameter
Field of view	TV Camera Option 1: 18° x 13.7° to 1.3° × 1° Option 2: 18° x 13.7° to 0.5° × 0.3° Thermal Imager: Option 1: Wide: 24.5° × 18.4° Medium: 7.2° × 5.4° Narrow: 2° × 1.5° Option 2: Wide: 16.4° × 12.3° Medium: 3.6° × 2.7° Narrow: 0.9° × 0.7°
Stabilisation applications	Four-axis gyro-stabilised

Rafael

Toplight

Rafael's Toplight family of sensors is derived from the front end of its IIten-ing targeting and navigation pod. The Toplite series can be used on naval, ground or airborne platforms, and is equipped with a thermal imager, a daylight colour TV camera, laser marker, and laser rangefinder (or a laser designator/rangefinder on Toplite III).


© Rafael

TOPLIGHT	
Platform	The Toplight system is being marketed for use onboard unmanned aerial vehicles and fixed wing patrol aircraft.
Payload weight	59 kg
Dimensions	662 mm (594 mm from mounting surface) x 406 mm
Field of view	Toplite II narrow FoV 1.3° × 1.0° (320 X240 FPA) Toplite II medium FoV 4.6° × 3.5° (320 X 240 FPA) Toplite II wide FoV 24° × 18° (320 X 240 FPA) Toplite III narrow FoV 1° × 0.77° (640 X 480 FPA) Toplite III medium FoV 4.4° × 3.3° (640 X 480 FPA) Toplite III wide FoV 24° × 18° (640 X 480 FPA
Stabilisation applications	4-axis gimbals

Sagem

Euroflir

The Euroflir is available in two versions: the EUROFLIR 350, which has a 350 mm diameter gimbal, and EUROFLIR 410, which has a 410 mm diameter gimbal. Both systems can accommodate up to four payloads, including: a thermal imager, HD TV colour camaera, laser range finder, and laser pointer.


© Sagem

EUROFLIR	
Platform	EUROFLIR 350: Helicopters, fixed-wing aircraft, UAV's. It is qualified on the French Army EC725 Caracal and AS532 Cougar, and it is used onboard Sagem's tactical UAV, Sperwer Mk.II. EUROFLIR 410: Several variants of French NH90 helicopters; it is also installed on the French Navy's AS565 Panther.
Payload weight	EUROFLIR 350: <32 kg EUROFLIR 410: <45 kg
Dimensions	EUROFLIR 350: 35.5 cm (14 in) EUROFLIR 410: 41 cm (16 in)
Field of view	EUROFLIR 350 and EUROFLIR 410 Thermal Imager: 1.3° up to 24°; UNFOV: down to 0.16°
Range	EUROFLIR 350 and EUROFLIR 410: range for detecting people: 3,000 m for identification; 6,500 m for recognition; 1400 m for detection EUROFLIR 350 range for detecting vehicles: 5,500 m for identification; 9,500 m for recognition; 18,000 m for detection EUROFLIR 410 Thermal Imager (Spectral): 3-5µm or 8-12µm
Stabilisation applications	EUROFLIR 350 and 410: 4-axis stabilized gimbal

Selex Galileo

Titan 385ES and 385es-HD Multi-Sensor Turret System (MSTS)

The Titan 385 Multi-Sensor Turret System (MSTS) is part of the MSTS family of sensors from Selex Galileo. Its sensor package includes an infrared camera, a colour TV camera, a solid-state low-light television camera and an eye-safe laser rangefinder.

Available options include a laser illuminator and a low-light spotter scope.
Variants include the Titan 385ES, which has enhanced stabilisation, as well as the Titan 385ES-HD, which replaces the existing thermal imager with a SLX Merlin thermal camera.

The Titan 385ES turret has an enhanced stabilisation feature, while the Titan 385ES-HD sees the existing SiGMA thermal imager replaced by the SLX Merlin thermal camera.

© Selex Galileo

TITAN 385ES	
Platform	The UK Royal Air Force (RAF) has ordered the Titan 385 for its C-130K Hercules C.1 airlifters. Titan 385ES has been Ordered for RAF Chinook HC.2 and Merlin HC.3 helicopters, Malaysian Navy Super Lynx 300 and German Navy Super Lynx helicopters. Titan 385ES-HD has been selected for the RAF Chinook upgrade under Project Julius in November 2009.
Payload weight	48kg (System Controller additional 3kg)
Dimensions	385 mm diameter
Field of view	Thermal Camera on Titan 385ES: Narrow FoV: 3.6° × 2.8° (on 640 × 512 FPA) Wide FoV: 18° × 14.4° (on 640 × 512 FPA); Colour TV camera Titan 385ES and 385ES-HD: 18° to 0.9° (auto-matched to thermal camera field of view)
Range	Thermal camera Spectral range for 385ES and 38ES-HD 3 to 5 μm Low Light TV camera Spectral Range for 385ES and 38ES-HD 450 to 1,100 nm
Stabilisation applications	three-axis gyro-stabilized

Thales

Airborne Gyro-stabilised Infrared Light Equipment (AGILE)

AGILE comes in to versions; AGILE 2 for helicopters, light aircraft and smaller UAVs, and AGILE 4 for larger fixed-wing aircraft and UAVs. The system includes a thermal imager, daylight colour CCD TV camera, laser range finder and laser range pointer.

AGILE	
Platform	AGILE 2 has been demonstrated onboard the Schiebel Camcopter S-100 rotary wing aerial drone.
Payload weight	AGILE 2: 20 kg AGILE 4: 24 kg AGILE 4 HD: 26 kg
Dimensions	AGILE 2: 30 cm diameter AGILE 4: 33 cm diameter AGILE 4 HD: 36 cm diameter
Field of view	Thermal Imager: AGILE 2: 27° x 20° (wide); 2.2° x 1.6° (narrow) AGILE 4: 27° x 20° (wide); 1.2° x 0.8° (Narrow) AGILE 4 HD: 27° x 20° (wide); 0.8° x 0.6° (Narrow) Colour TV: AGILE2: 42° x 32° (wide) ; 1.6° x 1.2° (narrow) AGILE 4: 14° x 10° (wide) ; 0.7° x 0.5 (narrow) AGILE 4 HD: 20° x 15° (wide) ; 0.5° x 0.3° (narrow)
Range	Thermal Imager (spectral) : 3 to 5 μm Colour TV (spectral) : 450 to 750 nm Laser target illuminator (spectral) : 800 nm - Range: 10 km Laser range finder (spectral) : 1.54μm - Range: 20 km Laser Designator (spectral): 1.06 μm - Range: 5 to 15 km
Stabilisation applications	AGILE 2: 3-axis gyro-stabilised AGILE 4: 4-axis gyro-stabilised AGILE 4 HD: 4-axis gyro-stabilised

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Urals Optical Mechanical Plant (UOMZ)

Gyrostabilized Optical Electronic System (GOES)

UOMZ produces a large family of GOES turrets which carry a variety of sensors based on the airframe and mission for which they are selected.

The GOES-321M and GOES-342 turrets are reported to be in production for installation on Russian military aircraft. The GOES-337M, evolved from the GOES-321M, is designed for an Mi-17 helicopter upgrade.

GOES-321M includes an thermal camera and laser rangefinder; the GOES 342 and GOES 337M include thermal and TV cameras for day/night operations, in combination with a laser rangefinder.

GYROSTABILIZED OPTICAL ELECTRONIC SYSTEM (GOES)	
Platform	The GOES-321M was designed for Russian Mi-8/Mi-17 'Hip' armed utility helicopters. The GOES-342 was designed for combat helicopters, such as the Mi-24/-25/-35 'Hind' family. The GOES-337M is designed for upgrading the observation and siting system for the Mi-17 'Hip' combat helicopter
Payload weight	GOES 321M: 90 kg GOES 342: 185 kg GOES 337M: 108 kg
Dimensions	GOES 321M: 460 x 613 mm GOES 342: 460 x 613 mm GOES 337M: 464 x 624 mm
Field of view	GOES 321M: Azimuth: ±230° Elevation: +40 to -30° GOES 342: Azimuth: ±230° Elevation: + 25 to -115° GOES 337M: Azimuth: 230° Elevation: -110 to +30

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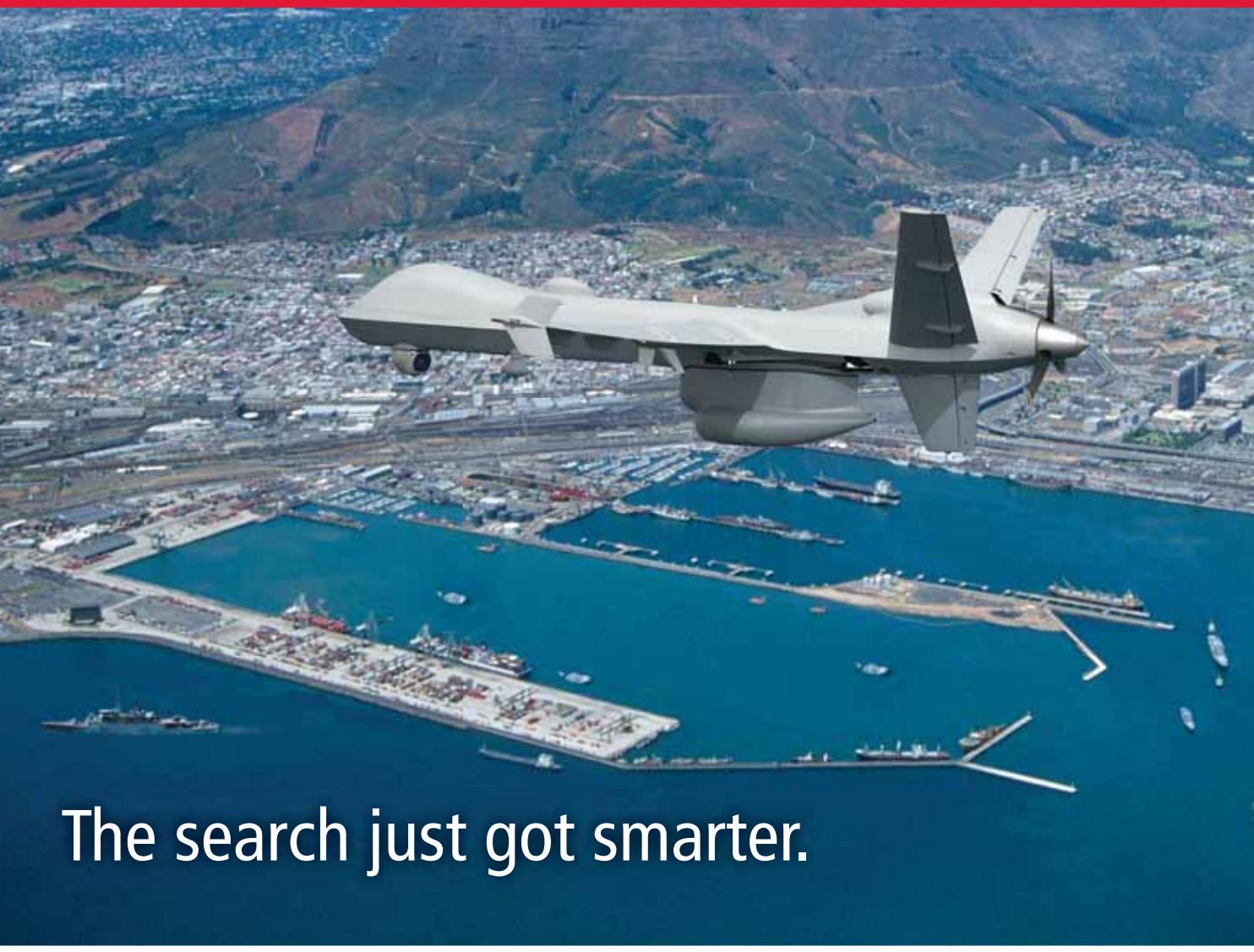
Maritime Surveillance Solutions



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- **Network Centric Operations:** Raytheon's MTS family of sensors offers a full range of integrated ISR systems, including many modes of intelligence collection and analysis. Air-to-ground net-centric platforms securely transfer near-real-time, actionable information, aiding mission command and control and enhancing the decision-making cycle. Raytheon also offers high-definition, full-motion video to the information consumer.

Raytheon's MTS family of sensors has been integrated on more than 16 platforms representing all Department of Defense branches and Department of Homeland Security assets. Numerous MTS family sensors are flying aboard U.S. Air Force unmanned air systems and on helicopters in the Navy and special operations fleets. The MTS is also currently in use in Italy, the United Kingdom, Singapore and Australia.

Raytheon Company, with 2010 sales of $25 billion, is a technology and innovation leader specializing in defense, homeland security and other government markets throughout the world. With a history of innovation spanning 89 years, Raytheon provides state-of-the-art electronics, mission systems integration and other capabilities in the areas of sensing; effects; and command, control, communications and intelligence systems, as well as a broad range of mission support services. With headquarters in Waltham, Mass., Raytheon employs 72,000 people worldwide.