Global Hawk & Triton & Future Next-Gen HALE EO/IR & Radars

Status: New Development
System Type: Airborne EO/IR & SAR (UAV)

Program Briefing

Raytheon developed the 400 kg Global Hawk Integrated Sensor Suite (ISS), which combines the HISAR synthetic aperture radar (SAR) with MTI (moving target indication), along with electro-optical (EO) and infrared (IR) sensors. The Enhanced ISS (EISS) is an upgraded sensor suite developed for the larger ***RQ-4B Global Hawk***, reportedly with a 50% greater range than the Basic ISS, for both EO/IR and SAR. EO/IR improvements include an improved telescope with better optics and real-time focus control. The SAR has an increase in transmitted power and a larger antenna. EISS production continues for the final Block 30 Global Hawks.

In this report, we also look at sensors for future Global Hawks, such as for the US Navy's MQ-4C Triton and for future Next-Generation HALE (High Altitude Long Endurance) UAVs.

In February 2012, the FY13 budget cancelled future USAF Block 30 Global Hawk production after the 18 air vehicles already contracted, and the Air Force planned to retire (mothball) the entire Block 30 Global Hawk fleet once production was complete.

But in March 2014, the FY15 budget restored Global Hawk funding, choosing instead to quickly retire the much more capable manned U-2 fleet. Many Air Force commanders criticized this decision, realizing they would lose the greater (and then cheaper) ISR capability. The decision was essentially a political one by the Air Force command.

In February 2015, Global Hawk program stability was essentially maintained, to be followed in February 2016 by many new planned upgrades and a great deal of new funding in the FY17 USAF budget. While these are being developed, U-2 retirement was moved right, then planned for 2019 but likely to stretch farther to the right.

In February 2018, the USAF FY19 procurement budget stated the designed service life of the Block 30 Global Hawk is approximately 25 years with an average service life remaining of 14 years – through 2032. And the USAF Global Hawk Program Office is exploring options to extend the service life.

By 2016 (and continuing today), U-2 and Global Hawk sensors were converging – the best U-2 sensors are now transitioning to Global Hawk, and substantial Global Hawk upgrade funding may result in improvements that then transfer back to U-2…. In early 2015, Lt. Gen. Robert P. Otto, the Air Force's Deputy Chief of Staff for ISR, stated U-2 sensors have a range of about 160 km, with Global Hawk's sensor range of about 95 km, apparently referring primarily to EO sensors.

This means Raytheon's Enhanced Integrated Sensor Suite (EISS) will probably begin to be retired on some Global Hawks, fairly soon. But a full replacement is unlikely, at least in the near term, and upgrades and support for EISS systems will continue. In fact, production of new EISS systems will continue into the next decade, recently for the three final USAF Block 30 Global Hawks, and for the first FMS Global Hawk buys, for South Korea and Japan.

In April 2008, Northrop Grumman won the $1.2 billion BAMS (Broad Area Maritime Surveillance) unmanned aircraft system (UAS) SDD contract, based on a modified Global Hawk (now designated the ***MQ-4C Triton***). Due to the different maritime mission of BAMS, Northrop Grumman has developed a new surveillance radar, the AN/ZPY-3 Multi-Function Active Sensor (MFAS) active electronically-scanned array (AESA) SAR/ISAR.

Triton/BAMS will place relatively less emphasis on the EO/IR sensor, and will mount a smaller Raytheon system derived from the AN/AAS-52(V) in production for Predator, Reaper, and Sky Warrior UAVs. Our forecast for Triton EO/IR is in the AN/AAS-52(V) report.

In April 2018, the US Defense Security Cooperation Agency (DSCA) notified Congress of a $2.5 billion potential foreign military sale (FMS) of four MQ-4C Tritons to Germany. And in June 2018, the Australian government confirmed that it would acquire six MQ-4C Tritons (not seven as planned), with the first to enter service in 2023.

Whatever happens to Global Hawk and Triton, there will eventually be future development and production of unclassified ***Next-Generation HALE (High Altitude Long Endurance) UAVs***, probably larger in size than General Atomics' Predator B Reaper and Predator C Avenger. The USAF's semi-stealthy MQ-X program was already in the planning stages, but has now been delayed or cancelled (and in part gone classified), while a follow-on to Global Hawk is some years farther out.

This report also evaluates and forecasts funding for speculative unclassified ***Future Next-Generation HALE EO/IR and Radars***, which we expect will continue to run parallel to major classified programs such as the US Air Force's new, stealthy RQ-180.

Executive

US Air Force

US Navy

Manufacturers

Primes

Raytheon Network Centric Systems
El Segundo, CA

(ISS/EISS; HISAR; Triton EO/IR)

Northrop Grumman

(Triton MFAS)

United Technologies
UTC Aerospace Systems (UTAS)
Chelmsford, MA 01824-4142
tel: (978) 967-2293
fax: (978) 967-2205

(U-2/Global Hawk EO/IR)
(was Goodrich)

Subcontractors

- Goodrich (was Recon-Optical, Inc., IL): EO camera in ISS and EISS

Functional Description

Global Hawk Program

The USAF's Global Hawk High Altitude Unmanned Aerial Vehicle conducted its first flight in February 1998, and a second Global Hawk made its maiden flight in November 1998. A total of five prototypes were built through 1999, with two more pre-series aircraft procured with FY01 EMD funds. Series production was first funded in the FY02 budget.

Unlike the Predator and Predator B, Global Hawk is to remain unarmed, and will serve entirely as a reconnaissance platform, similar to the U-2.

In mid-2005, the Air Force's plan for a series of evolutionary upgrades called "spirals" was shifted back to a more traditional procurement scheme, with Global Hawks stabilized into blocks. The older "A" models are now designated Block 0 and 10, while the larger payload RQ-4B aircraft will be Block 20, 30, and 40. Those blocks will primarily refer to changes in payloads and not changes in the air vehicle.

The initial Global Hawks produced under the advanced concept technology demonstration (ACTD) and a follow-on contract are known as YRQ-4A Block 0. Four of these aircraft survive, but are not expected to see much more operational use.

The USAF took delivery of the last of seven initial RQ-4A Block 10 aircraft in June 2006. Three of these have been accepted operationally: two at a forward operating location (believed to be Al Dhafra in the UAE) and a third has not flown since it was delivered to Beale Air Force Base (AFB) in late 2004, where it is in use as a maintenance trainer. The remaining aircraft have been delivered to the US Navy for the Global Hawk Maritime Demonstration (GHMD) program. The Block 10 has minor improvements over the YRQ-4A. In FY07, the Block 10 aircraft are expected to be able to maintain a single 24-hour orbit over the Middle East. The Air Force will apparently procure more Block 10s to fill out its LRIP requirement, until the larger RQ-4B is ready.

The initial version of the larger-winged RQ-4B, the first of which is due to fly in 2006, is the Block 20. Six of these aircraft are to be delivered, followed by 26 Block 30 aircraft. The RQ-4B has a 3,000 lb. payload capacity versus 2,000 lbs. for the RQ-4A, and a power increase from 10 KVA to 25 KVA available for sensors.

The Block 20 will mount the Enhanced ISS (EISS), and a limited signals intelligence (SIGINT) capability. Block 20 will have an open systems architecture (OSA), and a sensor management system rigorously separated from the vehicle management system (VMS), with power and local area network connections for changing out or upgrading sensors.

The Block 30 will add the Airborne Signals Intelligence Payload (ASIP) SIGINT package.

The Block 20/30 versions are expected to be supporting imagery intelligence (IMINT) orbits in FY09, including the first Global Hawk units to be deployed to the Pacific and European commands. By FY12, with 26 vehicles delivered, the Block 20 and Block 30 variants will be supporting four IMINT orbits and two multi-intelligence orbits with SIGINT.

The final version of Global Hawk will be the Block 40, with the Multi-Platform – Radar Technology Insertion Program (MP-RTIP) radar. The 15 Block 40s will carry only the radar, which will require almost all the weight, power and cooling capacity on the aircraft.

BAMS/Triton Program

The US Navy's Broad Area Maritime Surveillance (BAMS) program foresaw the use of UAVs as an adjunct to the manned Multi-mission Maritime Aircraft (P-8A Poseidon MMA) program, to pro-vide more persistent ISR in support of missions such as time-critical targeting. BAMS had its beginnings in 2002, and despite delays the concept has essentially continued as platforms and sensors have developed.

The Navy's MQ-4C Triton UAV is intended to provide a persistent maritime ISR capability even when no other naval forces are present. In 2016, the US Navy stated the Triton's ability to perform persistent ISR within a range of 2,000 nm will allow the manned P-8A aircraft to focus on its core missions, Anti-Surface Ship Warfare (ASuW)/weapons employment and Multi-Intelligence (INT) operations. Navy Tritons will operate from five land-based sites worldwide.

Planned sensors are a maritime inverse synthetic aperture radar (ISAR), capable of classifying targets, an EO/IR system, electronic surveillance measures (ESM), and an automatic identification system (AIS). For maritime UAVs, especially endurance UAVs, the radar is the primary sensor, not the electro-optical payload. Maritime missions involve longer slant ranges, with detection and identification of ships the primary goal, rather than picking small targets out of ground clutter for medium range reconnaissance and targeting. A long-range SAR, which can pierce cloud and moisture, is more effective than an EO/IR payload, which will be secondary on endurance maritime UAVs.

Triton AN/ZPY-3 MFAS Radar

According to Northrop Grumman in 2016, the AN/ZPY-3 Multi-Function Active Sensor (MFAS) is a 360-degree field-of-regard active electronically scanned array (AESA) radar designed for maritime surveillance. The X-Band two-dimensional sensor features a combination of electronic scanning and a mechanical rotation, allowing the radar to spotlight a geographic area of interest for longer periods to increase detection capabilities of smaller targets, particularly in sea clutter. Northrop claims MFAS is the first radar system to provide full 360-degree persistent coverage of both open oceans and littoral regions from extremely long ranges (this has been done before, but with shorter-range systems).

MFAS operates with a rotating antenna that incorporates electronic scanning and provides mode agility to switch between various surveillance methods. These include maritime-surface-search (MSS) mode for tracking maritime targets and inverse-synthetic-aperture radar (ISAR) mode for classifying ships. Image-while-scan capability is used to interleave very short duration ISAR functions (ISAR snapshot and high- range resolution) during MSS scans. Two synthetic aperture radar (SAR) modes are used for ground searches; spot SAR for images of the ground and stationary targets and strip SAR for images along a fixed line.

Platforms

All these sensors are carried aboard the Northrop Grumman Global Hawk/Triton UAV, though not always simultaneously.

Funding History

RDT&E ($ Millions)	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18*	FY19**	FY20**
PE# 0305220F RQ-4 UAV										
Proj. #675145 RQ-4 Block 30	—	—	16.0	10.0	206.4	128.1	123.2	35.0	26.0	30.8
Proj. #675149 RQ-4 Capability Enhancements	—	—	—	—	—	—	114.0	167.7	195.7	178.4
PE# 0305220N MQ-4C Triton										
Proj. #4020 MQ-4 Triton	535.6	548.6	612.7	375.2	419.2	237.1	113.6	84.1	14.4	11.8
PE# 0305421N RQ-4 Modernization										
Proj. #2939 RQ-4 Modernization [MQ-4C Triton]	—	—	—	—	30.0	119.9	144.5	229.4	219.9	136.5

Procurement ($ Millions)	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18*	FY19**	FY20**
Air Force Aircraft Procurement (BA04): Other Aircraft										
RQ-4 Global Hawk	572.2	395.5	118.4	11.0	54.5	4.2	6.5	—	—	—
(number)	(4)	(3)	—	—	—	—	—	—	—	—
Air Force Aircraft Procurement (BA05): Modification of Inservice Aircraft										
RQ-4 Mods	205.2	89.2	7.0	9.3	21.4	50.0	32.0	44.0	23.7	4.9
#470013 Sensor Enhancements (Capability Improvement)	—	—	—	—	—	—	—	12.7	0.5	—
#470020 EISS Enhancements (Capability Improvement)	—	—	—	—	—	—	—	3.8	19.8	1.0
#470021 ASIP Increment II (Capability Improvement)	—	—	—	—	—	—	—	17.5	—	—
Air Force Aircraft Procurement (BA07): Aircraft Supt Equipment & Facilities										
RQ-4 Post Production Changes	—	—	—	—	—	—	0.1	86.7	40.6	130.6
Initial Spares	n/a	n/a	n/a	n/a	n/a	0.1	1.2	28.9	1.2	13.6
Navy Aircraft Procurement (BA04): Other Aircraft										
MQ-4 Triton	—	—	—	—	—	619.7	498.8	577.8	626.0	570.9
advance procurement —	—	47.2	—	67.7	54.6*	55.7	57.3	58.5	59.6	
(number)	—	—	—	—	—	(4)	(2)	(3)	(3)	(3)

**Appropriation*
***Request*

Costs

In April 2006, the GAO estimated the cost of an RQ-4A Global Hawk with sensor as $82 million (up from original estimate of $60 million). In June 2006, Northrop Grumman claimed costs were: Block 10 RQ-4A with sensor – $31.6 million; Block 20 RQ-4B with sensor –$45.9 million; Block 30 RQ-4B with sensor – $54.2 million; Block 40 without sensor [MP-RTIP] – $39.2 million (we suspect these are low-end accounting estimates).

EO/IR unit costs are estimated at: ***ISS – $9 million (without HISAR)***; ***EISS – $15 million (without HISAR)***; according to Northrop Grumman, costs were $8 million and $12 million in 7/06.

HISAR unit cost is estimated at $4.5 million (ISS) and $6 million (EISS); according to Northrop Grumman in 7/06, unit costs were $4 million and $5 million.

Global Hawk ground station cost is estimated at $14 million.

AN/ZPY-3 MFAS radar unit cost for the MQ-4C Triton UAV could be between $22-32 million (speculative).

In February 2016, USAF FY17 budget plans funding RQ-4 Post-Production procurement showed a unit cost of $12.4 million for the MS-177 sensor for Global Hawk in FY18. Sensor Interface Modules (SIM) for Global Hawk (which could presumably use upgraded U-2 sensors) cost $3.8-3.9 million each for the MS-177 SIM in FY18-FY19, and $3.2 million each for the Optical Bar Camera (OBC) SIM in FY19-FY20.

In May 2017, USAF FY18 budget plans funding RQ-4 Post-Production procurement showed a unit cost of about $10-12 million each for two MS-177A sensors for Global Hawk in FY18 – but considerable additional contractor costs and support raised the total procurement cost to $67.4 million for two sensors, presumably installed. Initial spares added a further $27.0 million. The MS-177A is thus, perhaps, a deceptively expensive system….

Program Overview

History

ISS Development

Raytheon (El Segundo, CA) developed the 400 kg Global Hawk Integrated Sensor Suite (ISS), which combines the HISAR Synthetic Aperture Radar (SAR) with MTI (Moving Target Indication), along with EO and IR sensors. The EO/IR system pairs a Raytheon third-generation FLIR with a Kodak digital CCD visible light camera.

Air Vehicle (AV) #6 was delivered in April 2002, along with the third ISS. The first full ISS was lost when AV #5 crashed. The second ISS was lost in July 2002 when the second Global Hawk crashed over Afghanistan due to engine problems. The Air Force has asked Raytheon for accelerated completion of additional ISSs after each loss.

Global Hawk ISS Too Expensive

In 2002, the USAF asked Raytheon to lower ISS costs. Otherwise, the Air Force suggested recompeting sensors or building U-2s instead. Raytheon claimed only 9 more ISSs were planned before MP-RTIP, and cited this as a reason for continuing the ISS as is. However, Teal Group forecasts many more Global Hawks and ISSs before MP-RTIP is ready, which will not meet its 2002 projected in-service date of 2008.

Global Hawk costs as of May 2002 (according Air Force sources) were: Global Hawk+ISS+ground station had grown fom $18-20 million to $48 million; with non-recurring expenses, the total reaches $70 million per Global Hawk. The ISS cost about $12 million in mid-2002 (a decrease from $13 million in early 2002).

Enhanced ISS

The Enhanced ISS is an upgraded sensor suite developed for the larger RQ-4B. It reportedly has a 50% greater range than the Basic ISS, for both EO/IR and SAR. EO/IR improvements include an improved telescope with better optics and real-time focus control. The SAR has an increase in transmitted power and a larger antenna.

The Block 20 EISS will use most of the RQ-4B's additional power for an interim "clip-in" signals intelligence (SIGINT) sensor, Hyperwide, developed by BAE Systems. Block 30 will replace this with the ASIP SIGINT suite.

Enhanced ISS LRIP

In October 2004, the Air Force Aeronautical Systems Center (ASC), Wright-Patterson AFB, OH, awarded Northrop Grumman a $207.7 million firm-fixed-price (FFP) contract modification to fund Global Hawk LRIP Lot 3, to include one Global Hawk RQ-4A production air vehicle with *one basic ISS*, two RQ-4B air vehicles, one Global Hawk production air vehicle with *one Enhanced ISS and Clip-in Sensor (Hyperwide)*, one Mission Control Element (MCE), one launch recovery element, *one basic ISS*, and support equipment and spares. The work is to be conducted in San Diego, CA, and is to be completed by October 2005. Contract funding will come from the Air Force Aircraft Procurement (APF) account (F33657-03-C-4310/PZ02).

Lot 4 LRIP Advance Procurement

In March 2004, the ASC issued Northrop Grumman a $50.7 million contract to provide for long lead parts/advance procurement for LRIP Lot 4 items, including RQ-4B air vehicles with *Enhanced ISSs and Clip-in Sensors (Hyperwide)*, one mission control element (MCE), one launch recovery element, and support equipment and spares. Contract financing will come from the Air Force Aircraft Procurement (APF) account (FA8620-04-C-3410).

HISAR Development

Raytheon's HISAR with GMTI, developed from the U-2 ASARS radar and the AN/APQ-181 on the B-2 bomber, was planned for all Global Hawk production before MP-RTIP. It will see continuing production at least until MP-RTIP is ready, near the end of the decade. HISAR is a turnkey multi-mission, real-time, multisensor, reconnaissance and surveillance system. It is already in service on several other platforms, primarily for border surveillance and maritime patrol.

The HISAR radar weighs about 250 kg, including an airborne work station (ie., less than this on Global Hawk). The radar has four modes of operation: wide area moving target indicator (WAMTI), SAR strip, SAR spot, and sea surveillance. WAMTI detects moving targets in a 10,000-square-km area in a 90-degree wedge ranging from 30 to 120 km. The SAR strip mode has a 6-meter resolution that covers a 37 km swath that can be positioned between the ranges of 20 to 110 km. The SAR spot mode has a 1.8-meter resolution covering 10 square km. The sea surveillance mode has a maximum range of 200 km.

The newest version, HISAR 2000, incorporates a new radar, with improved SAR resolution of 1-meter or better reported, and longer range, out to 200 km in SAR/GMTI modes. It also allows wider coverage.

Raytheon claimed to have sold more than 22 HISAR radars by the end of 2002, primarily for manned platforms including the Beech 1900D, King Air 200, Bombardier Dash 7 and Dash 8, and Grob Egrett.

BAMS Program

The US Navy's Broad Area Maritime Surveillance (BAMS) program foresees the use of UAVs as an adjunct to the manned Multi-mission Maritime Aircraft (MMA) program, to provide more *persistent* ISR in support of missions such as time-critical targeting. But the program has seen delays since its beginnings in 2002.

Planned sensors are a maritime inverse synthetic aperture radar (ISAR), capable of classifying targets, an EO/IR system, electronic surveillance measures (ESM), and a communications package. Essentially, for maritime UAVs, especially endurance UAVs, the radar is the primary sensor, not the electro-optical payload. Maritime missions involve longer slant ranges, with detection and identification of ships the primary goal, rather than picking small targets out of ground clutter for medium range reconnaissance and targeting. A long-range SAR, which can pierce cloud and moisture, is more effective than an EO/IR payload, which will be secondary on endurance maritime UAVs.

In August 2005, the Naval Air Systems Command (NAVAIR), Patuxent River, MD, awarded four contracts under the Persistent Unmanned Maritime Airborne Surveillance (PUMAS) capability broad agency announcement (BAA), in lieu of a request for information (RFI) for BAMS. Contracts went to The Boeing Co.; General Dynamics Advanced Information Systems, Dayton,

OH; Lockheed Martin, Saint Paul, MN; and Northrop Grumman Systems Corp., Bethpage, NY.

During an initial five-month period of performance, the selected companies will establish performance metrics for unmanned ISR, and examine capabilities necessary for optimal performance of ISR within a family of systems. After this, the Navy will downselect contractors for another 7 month study.

According to the Navy, PUMAS will not change the acquisition strategy for BAMS, but, due to "affordability issues", the Navy has deferred the initial operating capability of BAMS until 2013, "and so the RFI has been retracted".

In April 2006, the US Navy planned to issue draft RFPs for BAMS late in 2006, still aiming at IOC by 2013. BAMS has been essentially dormant since 2004.

Australian Global Hawk

Australia joined the US RQ-4A Global Hawk program as a potential element of its Joint Project 129, Broad Area Airborne Surveillance, subsequently renamed as Phase 1 of Project Air 7000, New Maritime Patrol and Response Capability. The main goal is to replace the existing AP-3C maritime patrol aircraft force of about 13 aircraft. A Global Hawk was deployed in Australia for trials in 2001. Phase 2 of PA7000 is a later manned maritime patrol aircraft.

Australia wanted to acquire 4-6 air vehicles and a decision was scheduled for 2004-2005, but Australia deferred its planned acquisition of the Global Hawk in 2003 by at least two years to consider merging its land and maritime surveillance requirements into a single platform.

Australia has also been considering the long term potential for the RQ-4A Global Hawk in conjunction with its Wedgetail airborne early warning radar aircraft. The PA7000 requirement is expected to be worth A$1 billion (US$770 million)

In mid-2006, the Global Hawk decision date was set for 2007-2008, with the system entering service in 2009-2011.

Coast Guard Deepwater Endurance UAV Sensors

The US Coast Guard's $25 billion, 20-year Deepwater program, awarded to a team led by Lockheed Martin and Northrop Grumman (and many other suppliers), will include procurement of 76 UAVs, including Global Hawks (perhaps leased) or other endurance UAVs, and 60-70 Bell Eagle Eye Vertical takeoff and landing UAVs (VUAVs).

A significant Deepwater roadblock until 2003 was the lack of FAA certification for the operation of Global Hawk over the US, but this was achieved in 2003. Nevertheless, Global Hawk acquisition probably won't occur until the middle of the next decade at the earliest. In the interim, the USCG has spoken of paying for data from UAVs operated from two land bases. These may be DoD operated facilities. The eventual requirement will probably total about four to eight air vehicles.

Deepwater Global Hawk sensors could be slightly cheaper than equivalent size military sensors, because targeting may not be as crucial. On the other hand, the Navy's BAMS sensors would make an obvious choice for Deepwater.

Global Hawk Sensor Pods Proposed

In June 2005, at the Paris Air Show, Northrop Grumman unveiled external sensor pods for the RQ-4B, which could carry a pod holding up to 1,000 lb (455 kg) on a station on each wing, according to Ed Walby, director of business development for Northrop Grumman's High Altitude, Long-Endurance Systems Enterprises. The pods could carry sensors to complement the Raytheon ISS. Northrop Grumman conducted preliminary wind-tunnel testing of a pod on a scale-model Global Hawk.

While the Global Hawk design has always included hardpoints on the wings to accommodate pods, Walby said there has been no requirement for pods so far from the USAF. NASA has reportedly been interested in using Global Hawk to deploy pods with temperature-sensing devices above the Earth to measure patterns of global warming and cooling. Such measurements would help to predict hurricanes and typhoons more accurately.

Global Hawk Test Schedule

In June 2006, USAF plans called for IOT&E for the Block 20 RQ-4B to begin around November 2008, to last for an undetermined period of time. Block 20 and Block 30 testing will overlap, again in an undetermined fashion.

Operational assessment of the Block 10 began in August 2005, and was continuing in mid-2006.

Navy GHMD Testing

In early 2006, the Navy tested its pre-BAMS GHMD Global Hawk, and located seaborne targets from 65,000 feet with its ISAR.

Global Hawk vs. Mariner: BAMS Round 1

In June 2006, "Trident Warrior '06" pitted Global Hawk vs. Mariner in their first head-to-head exercise. Mariner will mount a 360 degree Elta ISAR, replacing the Telephonics side-looking radar used in the Mariner demonstrator.

USAF Sensor Details

In July 2006, much technical detail regarding Global Hawks sensors was released.

The Block 10 RQ-4A HISAR has a peak power output of 3.5kW and weighs 290 kg, and requires 4.7 kW of 400Hz power and 1.3kW of 28V DC power. The Block 10 ISS weighs 100 kg and requires just over 0.58 kW of 28V DC power.

The Block 20 RQ-4B has unchanged power requirements for the EISS, but the upgraded HISAR has a peak power output of more than 3.5kW, with an increased power transmitter.

The larger Block 20 X-band HISAR antenna is housed in a bulged fairing immediately aft of the nose gear, offering a field of regard of +/-45 degrees either side of the aircraft in azimuth and +/-20 degrees in roll. It can cover up to 138,000 sq km (53,000 sq mi) a day in search mode from a range of more than 200km (110nm). It can search up to 15,000 sq km/min, detecting targets with a ground velocity of 4kt (7 km/hr) or more from a range of 100km (ie., not walking humans). It has a 10m resolution in search mode, again not sufficient for human movement. In 2km x 2km spot mode, however, resolution is 30 cm. SAR strip mode provides 1 m resolution. Data throughput for both Block 10 and Block 20 HISAR is around 30Mb/s, and can be compressed to 8Mb/s at 2bits per pixel.

The Block 10 ISS and Block 20 EISS both use the same Recon-Optical, Inc. EO camera and a Raytheon IR sensor. The EO system uses a commercial, 1,024 x 1,024 pixel Kodak digital silicon charge coupled device, and a Raytheon 640 x 480 3-5 micron indium antimonide FPA. Both EO and IR sensors are fed by a fixed 1.75m focal length reflecting telescope with a beam splitter and 254mm reflecting mirror. The difference between the ISS and EISS is in the material of the mirror, which can be more precisely focused, and the introduction of a real-time precise focus capability. Both systems use a step-stare scanning telescope and back-scan mirror, to provide the needed 6,000 pixel width. The entire system uses a gimbal mount derived from Raytheon's AN/AAQ-16/29, that can roll +/-80 degrees or move +/-15 degrees in pitch and yaw. It is stabilized to 3mrad, rather than the "standard" 20mrad, and can cover up to 104,000 km/day in wide-area search mode. Data throughput for both Block 10 ISS is around 400Mb/s, and can be compressed to about 40Mb/s using JPEG techniques.

Final ASARS-2A Delivered for U-2

The ASARS-2A upgrade, with final delivery in 3QFY07, may be the last major U-2 ASARS-2 funding, aside from maintenance & support.

USN/Australia BAMS Final SDD RFP

In February 2007, NAVAIR released the final BAMS System Development and Demonstration (SDD) RFP. Interested parties can view/download the RFP (N00019-07-R-0001), exclusive of the Performance Based System Specification (PBSS) and Technical Library (TL), posted on the NAVAIR website. The RFP also includes options addressing Australian unique objectives. The anticipated contract type is Cost-Plus-Award-Fee (CPAF); however, the option line items for TDPs/Data Rights are Firm-Fixed-Price (FFP). Contract award is anticipated in 1QFY08.

BAMS full operational capability will provide for up to five simultaneous orbits worldwide. Initial Operational Capability (IOC) for BAMS is defined as one base unit with sufficient assets, technical data, training systems, and enough spares and support equipment to operationally support one persistent ISR orbit. The desired IOC is FY14, however, the objective is to achieve IOC in FY13 or earlier. At IOC, the BAMS UAS missions will include, but are not limited to, maritime surveillance, collection of enemy order of battle information, battle damage assessment, port surveillance, communication relay, and support of the following missions – maritime interdiction, surface warfare, battlespace management, and targeting for maritime and littoral strike missions.

SOL is N00019-07-R-0001, due April 2007. Questions may be addressed to Ms. Stacy Bostjanick, PCO, tel: (301) 757-5931, email: stacy.bostjanick@navy.mil; and Ms. Clare Carmack, Contract Specialist, tel: (301) 757-5919, email: clare.carmack@navy.mil.

BAMS Radar Sensor Suites

In mid-2007, Lockheed Martin plans provided Mariner with the 360 degree Elta EL/M-2022 SeaWatch ISAR, mounted on a ventral pylon, replacing the Telephonics side-looking radar used in the Mariner demonstrator. The radar will have SAR, ISAR, and weather modes. It flew in the June 2006 tests. It is likely that Lockheed Martin bought the Elta radar for testing and the competition – because it was ready – but would recompete any real production radar, looking for a US-sourced system.

Global Hawk will carry the Northrop Grumman designed Multi-Function Active Sensor (MFAS) AESA SAR/ISAR radar, which will provide much commonality with the AN/APG-81 radar on the F-35 Joint Strike Fighter (JSF). The MFAS allows simultaneous multiple target tracking while also operating the ISAR surveillance mode. The BAMS Global Hawk would also carry the Automatic Identification System (AIS).

Boeing's BAMS 550 unmanned business jet proposal will carry a Raytheon radar system.

BAMS EO/IR Sensor Offerings

Northrop Grumman's Global Hawk competitor will carry the Northrop Grumman Night Hunter II EO/IR system, as well as the Automatic Identification System (AIS).

As of July 2007, Lockheed Martin's Mariner will carry a FLIR Systems. Inc. EO/IR system.

Boeing's BAMS 550 unmanned business jet proposal will carry a Raytheon EO/IR system.

More USAF Global Hawks

In February 2008, the Air Force's FY09 unfunded requirements list included $616 million for five more Global Hawks – three Block 20 and two Block 30 – which would allow the USAF to deliver these capabilities three years earlier than planned.

In August 2008, the USAF had reportedly increased its Global Hawk requirement from 54 to 78 air vehicles, with funding expected in the FY10 budget request.

Northrop Wins $1.2B BAMS SDD

In April 2008, NAVAIR awarded Northrop Grumman's Integrated Systems in Bethpage, NY a $1.2 billion cost-plus-award-fee (CPAF) estimated contract to fund the system development and demonstration of the BAMS unmanned aircraft system (UAS), with the workload to include the design, fabrication, and delivery of two unmanned aircraft with mission payloads and communication suites; one Forward Operating Base Mission (FOBM); one Systems Integration Laboratory; and one Main Operating Base Mission Control System (MOB MCS).

The work is to be conducted in Bethpage, NY (30%); San Diego, CA (25%); various unidentified locations in the US (13%); W. Salt Lake City, UT (9%); Rolling Meadows, IL (7%); Falls Church, VA (6%); Baltimore, MD (5%); and Norwalk, CT (5%), and is to be completed by September 2014. Contract funding is to come from the Navy Endurance Unmanned Aerial Vehicles program (PE# 0305205A) (N00019-08-C-0023).

BAMS MFAS Goes Ahead

In mid-2008, Northrop Grumman's Multi-Function Active Sensor (MFAS) active electronically-scanned array (AESA) SAR/ISAR was the planned BAMS radar. The belly-mounted MFAS operates in the same 8-12.5 GHz band as Northrop's MP-RTIP. Its antenna rotates mechanically through 360 degrees; this 360 degree search capability was not offered by the other BAMS competitors, and some believe this was a major reason for Northrop's win. MFAS reportedly is derived from Northrop's earlier AN/APY-6 radar, though it also provides some commonality with Northrop's AN/APG-81 radar on the F-35 Joint Strike Fighter (JSF). The MFAS allows simultaneous multiple target search, tracking, and target data handoff while also operating the ISAR surveillance mode. In 2007, Northrop Grumman conducted its own risk reduction demonstration program.

BAMS sensor availability is planned in three increments. Increment 1 includes basic communications (wideband voice, VHF, and UHF) and the MFAS with moving target indication (MTI). Increment 2 will upgrade small object detection in heavy seas. Increment 3, ready by 2018, will an EP-X compatible SIGINT capability

Potential BAMS International Sales

In mid-2008, Australia was still expected to be the first international buyer, and might join the SDD program as well. Britain, Canada, Singapore, and Japan are also considered possible buyers.

BAMS Plans

As of mid-2008, the first BAMS air vehicle was planned to fly in mid-2011, with LRIP in 2013, operational evaluation set for FY14, and a full operational capability of five 24-hour orbits in place (20 air vehicles) by FY19.

The $3 billion program was slated to buy at least 48 Global Hawk UAVs. Total numbers have not been finalized, but the full program has planned up to 68 air vehicles.

Over the next five years, the Navy plans to spend $2.3 billion on RDT&E and $780 million on procurement.

Global Hawk Test Schedule

By May 2008, a Block 20 Global Hawk had executed more than 30 test flights, including a 33.1 hour endurance flight.

A Block 30 (with ASIP) was to begin testing in mid-2008.

A Block 40 is to begin flight-testing with MP-RTIP in mid-2009. MP-RTIP radar system level performance verification (RSLPV) completion has slipped from May 2008 to a planned February 2009, aboard the Proteus testbed. Delays are due, in part, to completing testing of all four radar modes.

Block 20 Delivered

In June 2008, Northrop Grumman delivered the first Block 20 Global Hawk to the USAF.

Spain Requests Global Hawk

In July 2008, after a year of consideration, the US State Department okayed the sale of the Global Hawk to Spain, probably five air vehicles and ground support equipment. The exact configuration is not certain, but the Block 30 with an undetermined SIGINT sensor is likely.

Australia Out of BAMS Due to Delays

In March 2009, Australia announced it would not invest in the next phase of BAMS development. Australia has plans to replace its manned AP-3C Orion maritime patrol aircraft around 2015, and when BAMS IOC slid back from 2013 to 2015 at earliest, Australia felt overlapping budget and other pressures would complicate AP-3C replacement.

EO Sensor Upgrades

In June 2009, the USAF Unmanned System Update planned enhancements to Global Hawk EO/IR cameras.

Platform Schedules

In June 2009, the first Block 40 Global Hawk was rolled out, with three others in various stages of production; MP-RTIP was 9 months behind schedule by late 2009.

Flight testing of the Block 20/30 Global Hawk only restarted in September 2009, after being put on hold in May following a spoiler malfunction; the first Block 30, carrying ASIP, is planned to enter service in 2010 or 2011.

BAMS Testing Continues; MTS-B Chosen

In 2010, testing continued for the BAMS sensor suite, including MFAS, Raytheon's MTS-B with an Automat-

ic Identification System (AIS) for ship tracking, and an ESM (electronic support measures) system.

MFAS Testing

In 2010, the Navy commissioned an independent MFAS assessment from the MIT Lincoln Laboratory, which compared well with Northrop Grumman's modeling. The Navy has been using a leased Gulfstream G-II manned aircraft for early MFAS flight testing.

BAMS MFAS Testing

In April 2011, Northrop Grumman announced it had commenced laboratory MFAS testing in Norwalk, CT. The first two radars were scheduled for delivery to Northrop's facility in San Diego, CA in June and September 2011, with risk reduction flight tests aboard a surrogate aircraft scheduled for late in 2011.

IOT&E: Poor EISS Performance

In May 2011, the Global Hawk IOT&E report found Global Hawk to be "effective with significant limitations…not suitable and partially mission capable." Many problems were reported, including poor performance of the EISS infrared sensor at range. The sensor operates well over a target, but slant-range performance is poor (the U-2 is considered to have excellent IR slant-range performance).

However, according to the Air Force's chief tester, Maj. Gen. David Eichorn, the Pentagon has already decided that "the [EISS] sensors are what the sensors are", and major fixes are not planned.

According to Eichorn, the EISS "HISAR" radar performance is good, if the aircraft is close to the target.

South Korean MoU for Four Global Hawks

In October 2011, Northrop Grumman signed memoranda of understanding (MoU) with four South Korean companies in support of its planned sale of four Block 30 Global Hawks to South Korea. The sale is reportedly awaiting formal US government approval.

Global Hawk Imagery Problems

In late 2011, USAF sources admitted there have been image quality problems with Global Hawk sensor data fed through the DCGS C4I system. These problems have been due to software, not sensors, according to the Air Force, including flaws in data processing and digital image "stitching".

Block 30 Finally Cancelled

In February 2012, the FY13 budget cancelled future USAF Block 30 Global Hawk production after the 18 air vehicles already contracted (14 delivered, 4 on order). I guess we should have seen this coming, considering the continuing problems and cost increases, as well as last year's truncation of Block 40 production.

On the other hand, nothing is set in stone and the Air Force could always restart production in the next presidential term (just as for the Block 40), perhaps after JSF funding is more secure following budget reductions. Certainly, its claim that it will simply warehouse the billion dollars of Block 30s already ordered is highly suspect.

Fortunately for a sensor forecaster, exactly how many Global Hawk air vehicles are built, and who gets them (transferred to the Navy for BAMS? Coast Guard? AGS? Eurohawk? Australia? South Korea? Garage sale?), is not as important as what and how many sensors are built. For now, we have simply split off our previous USAF Block 30 EISS forecast in the out years to an Undetermined line. Our forecast is probably still conservative, as certainly the possibility of a classified stealthy HALE UAV, or accelerated MQ-X production, will be worth at least 4 sensors per year through our forecast period.

However, this removes Raytheon's lock on HALE EO sensor buys, and given the issues with EISS performance, there will likely be serious competitions for future programs. Expect Goodrich to be highly competitive with a version of its SYERS sensor on the U-2 and other platforms. FLIR Systems, Inc. and L-3 WESCAM will no doubt develop systems, but so far they have not played in the high-altitude arena. Teaming to battle the Raytheon juggernaut could be highly beneficial here. There is also the possibility that old-school fighter tac recce suppliers such as BAE Systems could compete, probably teamed with other sensor and/or C4I firms.

HISAR Future in Doubt

By early 2012, HISAR production was well underway for Global Hawk, but the Air Force's decision to cancel future Block 30s after the first 18 air vehicles (already contracted) is a serious blow to HISAR. Always a little-known system, follow-on production for Global Hawk, or future production for a new HALE UAV, will likely be competed. There are several new small SARs now being developed or entering production, and we have little confidence that HISAR will dominate the future. We have thus added an Undetermined production line for HISAR-similar systems, but there is a good chance these will be for a new radar. There is also a chance these will be classified programs.

South Korea Cancels: Block 30 Too Expensive

In January 2012, South Korea decided not to buy Global Hawk, reportedly due to the offered price of $220 million per air vehicle. The decision came just before the USAF cancelled its own Block 30 program. Korea planned to now open its competition to AeroVironment's Global Observer and Boeing's Phantom Eye. However, if the USAF really plans to mothball its already-built Block 30 fleet, some of these could eventually wind up with Korea or other buyers.

Polar Hawk: Northrop Cold-Calls Canada

In June 2012, Northrop Grumman made an unsolicited proposal to Canada to provide three modified Block 30 Global Hawks for surveillance of the country's Arctic territories (to include national security, scientific research, and search and rescue roles).

The proposal coincided with the Canadian National Defense Department's attempt to restart its long-delayed Joint Unmanned Surveillance Target Acquisition System (JUSTAS) procurement of armed UAVs, but the revised JUSTAS acquisition omitted the originally-planned second phase for Arctic surveillance, hence Northrop's unrequested proposal (whether Northrop plans to transfer already-built USAF Global Hawks from [proposed] storage is unclear).

Sensors proposed include the Raytheon EISS as well as a satellite communications suite optimized for Arctic operations.

Northrop Grumman has teamed with Canadian military-aircraft support provider L-3 MAS for Polar Hawk.

Global Hawk: Origins of JSF Concurrency Disease?

According to the GAO in March 2012, the Global Hawk program has utilized a concurrent testing and production strategy, which put it at increased risk of cost growth. The program procured all of its Block 20 and more than half of its Block 30 aircraft before completing operational testing in 2010, and plans to procure all of its Block 40 (MP-RTIP) aircraft before it begins operational testing in October 2013.

Also according to the GAO, planned total program RDT&E in March 2001 was $1.0 billion. By October 2011, this had increased to $4.8 billion, with $1.7 billion yet to be spent. Procurement had increased from $4.3 billion to $7.9 billion, with $3.1 billion yet to be spent, all for a reduced production run of 55 (originally 63) aircraft.

Whether or not existing Block 30 aircraft are retired, Global Hawk Block 40 production is scheduled at end in 2015.

In March 2012, an upgraded ground station and communications subprogram was scheduled to begin system development in summer 2013.

USAF Block 30 Retirement: Not in Cold Storage Yet

In September 2012, reports indicated the Air Force had issued an RFP to Northrop Grumman to extend support for operational Block 30 Global Hawks until September 2013. According to Air Force sources, the aircraft will remain in service until Congress makes a final decision on budgets. The Block 30 fleet stood at 14 aircraft, with four more in production, and three additional aircraft already authorized by Congress.

Global Hawk Block 30 Status Undecided

In early 2013, the USAF was still undecided on plans for the Block 30 Global Hawk fleet. Earlier in the year, the Air Force issued a sole-source RFP to Northrop Grumman to extend support for the Block 30 through September 2013.

In December 2012, Secretary of Defense Leon Panetta was still suggesting that terminating further acquisition of Global Hawk would save billions of dollars.

South Korea Requests Information

In December 2012, the US DSCA notified Congress that South Korea had requested information on a possible $1.2 billion buy of four Global Hawk UAVs, including associated equipment and services. These would be Block 30(I) versions, with the EISS.

South Korea has long been considering a Global Hawk buy, but has so far turned it down due to cost and reliability concerns. The US currently flies Global Hawks over Korea, but is due to transfer overall command of forces in the area to the South Korean military in 2015.

Japan Eyes Global Hawk

In January 2013, according to Kyodo News, Japan seemed to be considering a rush procurement of Global Hawk (to be introduced by 2015), to allow better surveillance of its territorial waters and islands in the East China Sea, especially the Senkaku Islands.

Block 20s Bringing Home the BACN

As of April 2013, at least three Block 20 Global Hawks had been converted to Battlefield Airborne Communications Node (BACN) air vehicles, and continued in service under Congressionally imposed funding. BACN, first flown in July 2010, provides an internet protocol (IP) based communications relay and information server to link radios and ISR systems for DoD networks. Their EISS and HISAR systems have been removed.

Congress Keeps Global Hawk Flying

In April 2013, Congress denied the USAF plan to retire and warehouse Block 30 Global Hawks, insisting that the Air Force Secretary "shall maintain the operational capability" of each Block 30 air vehicle out to December 31, 2014. According to USAF procurement documents: "Additionally, the program will ensure that procurement efforts will support the continued operational capability of each RQ-4 Block 20/30/40 air vehicle through Dec 2014 as directed in 2013 NDAA."

But Production Line Closing

The Senate did, however, allow the Air Force to plan to phase out the Block 30 in the future. From USAF procurement documents: "This funding supports Global Hawk costs to shut down the Production line (to include tooling disposition, contract closeout, sustaining engineering ramp down, mission support and production closeout costs, etc.). This raises the question of where new Global Hawks for FMS would be built, but presumably it is only USAF facilities relating to Global Hawk production that will be closed down.

BAMS Dodges Global Hawk Bullet?

According to BAMS program officials, the BAMS air vehicle is based on the Air Force's RQ-4B Global Hawk with some structural changes to the airframe, but none of these require significant changes to manufacturing processes.

As of early 2012, the BAMS program had not reported any negative effects as a result of past challenges in the Global Hawk program, though cancellation of the Global Hawk Block 30 program had not been assessed. According to the Navy's BAMS program office, the performance and reliability issues experienced by Global Hawk during operational testing had already been addressed for BAMS.

In addition, the BAMS program had reported to the Navy on the potential cost effects of reduced Global Hawk procurements which occurred after that program experienced a Nunn-McCurdy unit-cost breach of the critical threshold in 2011. Projected BAMS costs have not risen significantly.

Global Hawk/BAMS Shared Operations

Despite changes to the USAF Global Hawk program, in early 2012 the BAMS program was continuing to investigate potential areas of commonality, including a common ground control station architecture, a consolidated maintenance hub, and co-located basing for both aircraft abroad.

Northrop Offers Unrequested BAMS to Australia

In February 2012, Northrop's BAMS business development leader, Walt Kreitler, discussed BAMS for the Royal Australian Air Force (RAAF), stating MQ-4Cs could be delivered by January 2016, despite the fact that Australia is no longer officially part of the BAMS program.

Production Schedule

In March 2012, the BAMS LRIP decision was planned for May 2013, with IOC planned for December 2015.

BAMS-D Demonstrators Successful for 5th Fleet

In mid-2012, Capt. James Hoke, the Navy's program manager for the Persistent Maritime Unmanned Systems Program Office, spoke of the successful use of BAMS-D Global Hawks to provide maritime surveillance for the Navy's 5th Fleet in the Persian Gulf, Red Sea, Gulf of Oman, and Indian Ocean. Beginning in January 2009, a planned six-month deployment has lasted more than 3 years, according to Hoke, and the Block 10 demonstrators have been both very successful and in-demand.

BAMS-D Crashes

In June 2012, one of the Navy's Block 10 BAMS-D demonstrators, operated from Patuxent River NAS, crashed along Maryland's eastern shore, about 20 miles from Salisbury, MD. Aerial video showed a Global Hawk-shaped indentation surrounded by burning debris at the swampy crash site. The cause was being investigated.

The first MQ-4C BAMS was to be unveiled that same week by Northrop Grumman at its facility in Palmdale, CA.

SDD MQ-4C Unveiled; Testing Plans

In June 2012, Northrop rolled out the first system demonstrator (SDD) MQ-4C BAMS air vehicle in Palmdale, CA – very different from the Block 10 demonstrator that crashed three days earlier.

First flight was planned by the end of 2012, with IOC in December 2015. Up to nine test flights will begin at Edwards AFB in restricted airspace, followed by a transit to Pax River, MD to complete development. The SDD 2 air vehicle will be about a month behind SDD 1, according to Northrop Grumman. SDD 1 is due to fly with all sensors, including MFAS, on its first flight.

MFAS Software Development Challenge Remains

BAMS poses a significant software development challenge, utilizing nearly 8 million lines of code, of which more than 20 percent will be newly developed for the program.

In early 2012, program officials cited software development as a primary risk for the new sense-and-avoid, air-to-air radar, but noted that they still expect it to be ready for the program's planned operational assessment in 2013.

MFAS Flight Testing

In 2012, MFAS was scheduled for 30 test-bed aircraft flights through 2012, ending in October. Flight tests began in December 2011, aboard a Gulfstream aircraft. Tests were to be in three phases: radar integration, mode integration and refinement, and data collection. Radar mode maturation seeks to improve detection, tracking and classification of maritime targets.

Northrop to Fund Own BAMS Test Aircraft

In January 2013, sources indicated Northrop Grumman had decided to build its own BAMS air vehicle to add to the test fleet. This analyst's cynical nature leads me to believe Northrop – and the Navy – are worried that if BAMS encounters the same delays that Global Hawk has, there is a good likelihood the Navy will cancel the program. Perhaps by devoting more time to testing and development, even on Northrop's dime, the whole program will survive. Frankly, if all contracts worked this way, the US would get much better value for money. Of course, once secure, the program could go back to delays and cost overages at the country's expense….

In fairness, recently – since the April 2008 SDD contract – BAMS has been remarkably on-schedule and on-cost. Northrop has so far done a much better job with BAMS than the

Air Force's Global Hawk. With USAF buys now all cancelled, we will see if Navy good behavior was real or sand-bagging.

Triton First Flight

In March 2013, Northrop Grumman anticipated an imminent first flight for the two Triton test aircraft, SDD-1 and SDD-2, which were in the "final stages of testing". It is already more than 15 years since Global Hawk's first flight, last century.

fcs1 = Triton Cleared for India

In early 2013, the US government cleared Northrop Grumman to begin preliminary discussions with the Indian navy on a sale of the MQ-4C Triton. As India already is receiving P-8I Poseidon manned aircraft – the other half of BAMS – Triton is an obvious choice for future long-endurance maritime surveillance.

Australia Reducing Maritime UAV Needs?

Also in early 2013, Australia was considering its future mix of maritime aircraft systems. Sources indicate the desire may be for more manned platforms – with the P-8 Poseidon the obvious choice – but perhaps fewer UAVs. Suggestions of 12 rather than 8 Poseidons might lead to reductions in the currently planned "up to" 7 UAVs.

USAF Global Hawks in Japan Following Mixed Reviews in Guam

In October 2013, the US planned to rotationally deploy "two to three" Global Hawks to Japan within the next 12 months, but provided no details regarding which base would be used. An undisclosed number of Global Hawks have been operating out of Guam, but have encountered problems transiting to operational areas across a stormy and Pacific ocean. Global Hawk's long range on paper has not translated into a reliable long operational range over the Pacific.

Funding Transfer GH to Triton Discussed

In November 2013, the US Navy and Air Force were discussing a transfer of FY12 USAF Block 30 Global Hawk funding to the Navy MQ-4C Tritons, according to government sources. About $300 million for three Global Hawks would be transferred to procure two Tritons. Reportedly, a transfer request could go to Congress in early 2014.

Japanese Global Hawk Plans

In December 2013, Japan announced $240 billion in new procurements over the next 5 years (a 5% increase over previous plans) as part of its "Dynamic Joint Defense Force" intended to maintain air and maritime security around its claimed islands in the South China Sea, including responding to "grey zone" situations.

The Japanese Ministry of Defense (MoD) plans to buy three HALE UAVs, previously expected to be Block 30 Global Hawks, but the new, even stronger stress on South China Sea operations will likely make the MQ-4C Triton a better choice.

The Japan Maritime Self-Defense Force (JMSDF) also plans to by 10 Kawasaki P-1 maritime patrol aircraft, with the first delivered in 2013. If Japan were buying Boeing P-8 Poseidons, Triton would be the obvious choice. Despite the P-1 not already being integrated as a BAMS node, Triton sensors, and expected future Triton development if the US Navy procurement goes ahead, will still likely make Triton a better choice for Japan, especially as the Block 30 EO/IR sensors have not performed brilliantly and Triton will have the MFAS radar.

Global Hawk vs. U-2 Sensor Parity

In March 2014, sources at the Pentagon reportedly announced that it would cost about $1.9 billion to upgrade the Global Hawk Block 30 to "parity" with the U-2 – almost as much as the Pentagon says it will save by retiring the U-2. DoD documents show a lower sum in planned funding for upgrade development, $258 million through FY19 and $489 million in continuing years, for sensors, C4I, and reliability and maintainability improvements.

Clearly, there will be winners and losers if this is true, and if Global Hawk does replace the U-2. The obvious winners will be sensor providers to upgrade 21 Global Hawks.

Korea Orders Four Block 30 Global Hawks

In December 2014, Northrop Grumman was awarded a $657 million FMS contract from South Korea for a fleet of four Block 30 RQ-4B Global Hawks, EISS sensor systems, and "applicable ground control environment elements." Work will conclude by June 2019.

South Korea also contracted for Israel Aerospace Industries Heron 1 UAVs in December 2014.

Global Hawk Here to Stay

In February 2015, after several attempts to retire the Global Hawk Block 30, the US Air Force included Global Hawk in its FY16 budget, roughly equivalent to the March 2014 budget, providing some stability to what had become a change-every-budget program. The Air Force had wanted to retire the Global Hawk and keep the U-2, but pressure from congressional allies of Northrop Grumman has reportedly been the major contributor to keeping Global Hawk in service.

The Air Force now plans to retire the U-2 in 2019, allowing upgrades to better prepare Global Hawk for the takeover. However, if Budget Control Act funding cuts return, the U-2 will be divested in 2016.

According to Northrop Grumman, Global Hawk cost per flying hour has halved in the past two years, which would mean it has gone from being more expensive and less capable to being cheaper, though still smaller and slower than the U-2. Speed matters for getting to distant mission areas, so Global Hawk's longer total endurance does not necessarily mean

longer endurance over targets. The U-2 also has a considerably faster reaction time.

EISS Next Gen Sensor Study: U-2 Sensors Considered

In early 2015, FY16 budget documents reported a Congressional Add of $10 million in FY14 to fund a study for Adaptation of U-2 Sensors for the RQ-4 Block 30. The study assessed the integration of U-2 sensors or alternative sensors of comparable capability onto the RQ-4B, including comparing how differences in flight performance would affect sensor performance (such as enhanced weather capabilities, and mission planning and airspace and sensor interoperability).

Universal Payload Adaptor to Allow U-2 Sensors?

In early 2015, one plan being considered to improve Block 30 Global Hawk sensor abilities was a Universal Payload Adaptor (UPA) to allow the use of U-2 sensors (including the multispectral SYERS-2B/C and the wet-film Optical Bar Camera) as well as new sensors.

In March 2015, Mick Jaggers, Northrop Grumman's Global Hawk program manager, said Northrop was already working on the adaptor using its own research and development money. Physical interfaces were "almost complete", with the proof of concept to be complete by the end of 2015. The next step will be testing with a sensor of the USAF's choosing, which in April 2015 was planned for November 2015.

The UPA system being developed has been described as a metal grid attached to the underside of Global Hawk, able to carry 3-4,000 lbs. of payload. Reportedly, SYERS-2 and the Optical Bar Camera combined weigh 1,500 lbs.

Maybe… for Lots More Money than you Think…

Teal Group agrees that a universal adaptor to allow changeable or modular sensors always sounds like a great idea, but has found that it rarely works in practice. Even podded sensors are either rarely swapped or rarely bought for more than one platform (such as the US Navy's "Shared Reconnaissance Pod" [SHARP]). Large modular sensor programs, such as the Mission Modules for the US Navy's Littoral Combat Ship (LCS), often just plan fail. Internal sensor fits are even more rarely swapped, and roll-on/roll-off sensor programs have generally died a quiet death. Small EO/IR, SAR, and SIGINT sensors could "easily" be provided as changeable, modular systems – a gimbal mount is essentially a universal adaptor. They have occasionally been planned, but rarely used in practice (on mini-UAVs, thousands of swappable EO and IR payloads were replaced with combined EO/IR sensors as soon as technologically feasible). The universal adaptor idea sounds great on paper, but if it is really such a great idea, why hasn't it been the plan from the start for all large UAVs with relatively small payloads?

In the case of Northrop's UPA proposal, of a "metal grid attached to the underside" of the Global Hawk, sensors would likely need to be totally reconfigured, podded, and tested anew (which is now underway in 2017…). You don't sling the sensor alone on the belly of an aircraft. Senior USAF officials previously have said it would take nearly $2 billion to upgrade Global Hawk sensors to reach U-2 capabilities. This was a number chosen to encourage Global Hawk retirement, but could be accurate, considering that Northrop's Mick Jaggers recently stated the UPA, "along with upgrades to ground and communications systems", could be provided for $1 billion.

Rather stunningly expensive for a "metal grid attached to the underside" of Global Hawk, and indicative of both the complexity of such a project as well as the likely absence of genuine cost-savings. With typical delays and cost increases, UPA could be a very expensive project and perhaps not much of an improvement – probably reducing Global Hawk endurance and perhaps altitude ability, even if attached sensor pods are carefully (and expensively) designed. It is also still primarily an attempt to simply equal the U-2. Swappable sensors – cool idea, but they rarely offer real benefits over dedicated sensors.

Block 30 EISS/ASIP Plans

In February 2015, PE# 0305220F in the FY16 budget planned for Global Hawk Block 30 EISS and ASIP mission planning development and testing, enhanced weather capability development and testing, airspace and interoperability enhancements and updates, airframe upgrades, sensor upgrades, risk reduction and integration, ice protection system development and testing, and resolution of issues with Diminishing Manufacturing Sources (DMS).

Specific sensor development plans include mission planning development and testing, completion of Synthetic Aperture Radar-Complex Imagery development testing, the next gen sensor study, enhanced weather capability development and testing, airspace and interoperability enhancements and updates, airframe and software upgrades and deficiency report resolution across RQ-4 fleet, sensor interoperability enhancements and upgrades, upgrades to the ASIP SIGINT sensor, Mode 5/ADS-B development and testing, development and testing activities associated with enhancing sensor capability and sensor integration, development and testing of ice protection systems, program protection projects, and studies and analysis supporting future system enhancements.

Global Hawk Still Without FMV or GMTI

A rarely mentioned fact during the U-2 vs. Global Hawk debate is that by mid-2015, Global Hawk's EISS still provided neither EO/IR full-motion video (FMV) nor radar moving-target detection (GMTI) capabilities, available on many smaller UAVs in US and world service.

Canada to Restart JUSTAS MALE?

In May 2015, after nearly a decade of delays, the Canadian Air Force was reportedly again considering beginning its major Joint Unmanned Surveillance Targeting and Acquisition System (JUSTAS) program, to buy an endurance UAV fleet to support a wide range of military and civil missions. As many as 18 UAVs have been planned, along with a 20-year in-service support package.

In April 2015, Canadian Air Force officials outlined a plan to have the first UAVs operational in 2021, with a contract award in 2019 and all air vehicles delivered by 2023. The UAVs sought could potentially range in scale from the Israeli Heron to the Northrop Grumman Global Hawk or Triton – but with a contract not expected until 2019, much will no doubt still change. And with all deliveries expected within four years of initial contract award, real procurements will no doubt slide right again.

Regarding the UAV required, a Department of National Defence audit in March 2014 noted that the Heron UAV that MacDonald Dettwiler and Associates (MDA) supplied to the Canadian military in Afghanistan would not meet today's JUSTAS requirements. Industry sources reportedly have long favored the General Atomics Predator, but with a new generation of post-Predator/Reaper UAVs now on offer, capabilities creep will likely inspire another long and painful competition. For example, General Atomics has already offered its semi-stealthy jet-powered Predator C Avenger.

Regarding sensors, the Canadian Air Force expects a sensor suite including full motion video (FMV) in color EO, IR, and low light, along with a synthetic aperture radar (SAR). The UAVs must be able to carry weapons, though Canada claims the primary mission will be ISR.

Triton MFAS to get GMTI?

In early 2014, the new National Defense Authorization Act recommended the Triton be able to perform missions for other military branches in addition to the US Navy. The Joint Chiefs of Staff are now required to study whether it is "feasible, affordable and advisable" to adapt the Triton to obtain GMTI information, similar to Block 40 Global Hawk MP-RTIP capabilities. The suggestion has even been made to reclassify the Triton as a joint DoD asset.

Northrop Grumman has said GMTI could be incorporated into the MFAS, or as a separate capability.

Australia Commits to Triton – Pending USN Success

In March 2014, Australian Prime Minister Tony Abbott announced, "The government has committed to the acquisition of the highly-capable Triton unmanned air vehicle, subject to the successful completion of the US Navy development program currently underway." Triton will be acquired under the Project Air 7000 Phase 1B program, as the unmanned element of Australia's P-3C fleet replacement, in concert with 8-12 P-8A Poseidon aircraft to be acquired from 2017 under Project Air 7000 Phase 2B (approved in January 2014).

As for the US Navy, Triton will conduct most high-altitude broad-area surveillance missions, while Poseidon performs anti-submarine and anti-surface warfare, search and rescue response, and electronic intelligence missions.

Exact numbers and introduction dates have not been announced, with changes possible in Australia's Defense White Paper scheduled for release in early 2015. Expectations are for 6-8 Tritons, with service entry not until 2020. Abbott also announced AUD 140 million of new facilities and infrastructure will be built for the Tritons.

USN Schedule Delays: One+ Year

In March 2014, the FY15 budget outlined technical challenges in the development program, combined with "sequestration-driven resourcing constraints", which led to the delay of production and other milestones, most by one year or slightly more.

PB15 shifted Milestone C from 1Q FY15 to 1Q FY16. Full Rate Production (FRP) milestone decision shifted from 1Q FY17 to 2Q FY18. Low Rate Initial Production (LRIP) 1 contract award shifted from 2Q FY15 to 2Q FY16 and LRIP 2 contract award from 2Q FY16 to 2Q FY17. FRP Lot 3 contract award shifted from 2Q FY17 to 2Q FY18 and FRP Lot 4 contract award shifted from 2Q FY18 to 2Q FY19. Initial Operational Capability (IOC) shifted from 3Q FY17 to 3Q FY18.

For actual radars, SDTA deliveries shifted from 1Q FY15 through 3Q FY15 to 4Q FY15 through 1Q FY16. LRIP 1 deliveries shifted from 3Q FY17 through 1Q FY18 to 2Q FY18 through 1Q FY19. LRIP 2 deliveries shifted from 2Q FY18 through 4Q FY18 to 2Q FY19 to 4Q FY19. Integrated Test shifted from 4Q FY12 through 3Q FY15 to 4Q FY12 through 1Q FY17. Operational Test Readiness Review shifted from 4Q FY15 to 2Q FY17. Operational Evaluation shifted from 1Q FY16 through 2Q FY16 to 3Q FY17 through 4Q FY17. Follow On Integrated Test was added from 1Q FY18 through 4Q FY19.

Northrop Opens Australian Subsidiary

In December 2014, Northrop Grumman officially launched its new Australian subsidiary, intended to support Triton UAV sales to Australia as well as rest of the Asia-Pacific region.

Triton Reductions Begin: FY16 Budget Cuts Total Buy by 7 Tritons

In February 2015, reality began to creep into US Navy plans, as the FY16 budget plan reduced the total planned Triton buy from 68 to 61 air vehicles. The 61st is still more than a decade away, so the numbers are still pretty meaningless, but at least this might help balance future expenditures and allow the Navy to buy some ships and subs without hiding them in supplementary budgets….

Regarding production and IOC schedules, current plans have largely stuck to the same delayed dates from March 2014, though System Demonstration Test Article (SDTA) deliveries shifted from 4Q FY15 through 1Q FY16 to 1Q FY17 through 2Q FY17.

Triton Flies with MFAS/AIS Sensors

In April 2015, an MC-4C Triton flew from Pax River NAS equipped with a sensor suite including the MFAS radar as well as the Automatic Identification System (AIS).

Triton MS C and IOC Plans

In April 2015, the Navy expected Triton Milestone C around December 2015, followed by operational evaluation and IOC in FY18.

Triton fielding is planned by the Navy under an "incremental upgrade" approach. Integrated Functional capability 1 (IFC 1), with a baseline sensor capability, began testing in 2014. The MFAS first flight in April 2015 was part of the IFC 1 effort.

Triton New/Improved Sensor Needs

In April 2015, Navy officials noted that Triton sensors will need to continue to reduce size, weight, power and cooling (SWaP-C). Officials also stated they are interested in adding the Software Reprogrammable Payload (SRP) on Triton, as well as a sensor that can track ships that the AIS system misses.

Recent History (Global Hawk)

Northrop Awarded $3.2 Billion Global Hawk Contractor Logistics Support Contract

In September 2015, the USAF's Air Force Life Cycle Management Center, Robins Air Force Base, GA (www.robins.af.mil/units/aflcmc), awarded Northrop Grumman Corp. a $3.2 billion contract to conduct upgrades, technology insertion, and maintenance of Global Hawk over the next decade, including configuration management, data management, technical refresh, and component-obsolescence issues for all Air Force variants of the Global Hawk, as well as depot maintenance for airframes and engines and parts repair and replacement.

Note that this is a contractor logistics support contract – arguably much more expensive than if the Air Force conducted its own maintenance with Air Force personnel. Many believe today's increasingly complex military technology benefits from contractor support and even operations. On the other hand, some believe this opens these programs to greater opportunities for corruption and waste – with a $3.2 billion bank account to play with – and that it blurs the line between the military legally entitled to prosecute a war, and private companies which in the United States have traditionally not been allowed to do this.

Northrop Grumman will conduct much of the work in San Diego, CA, continuing through September 2025.

Japan Global Hawk Anticipated

In November 2015, the US approved the sale of the Block 30 Global Hawk to Japan, including the EISS sensor suite. By early 2016, a purchase of three air vehicles and two ground control stations, worth about $1.2 billion, was anticipated. If a contract goes ahead as planned, delivery could begin in 2018-2019.

Korean Delivery Schedule

In mid-2016, Northrop Grumman indicated the four Global Hawks for Korea would be delivered in 2017 (2) and 2018 (2). South Korean suppliers, which are producing cable harnesses, brackets and other fixtures, had reportedly already delivered some parts.

Global Hawk Costs Drop Again

In mid-2016, reports indicated RQ-4 Global Hawk cost per flight hour had shrunk again, to $14,000 per hour. Cost was $32,000 per hour in 2012.

Global Hawk Block 30 RDT&E

In February 2016, USAF FY17 budget plans in PE# 0305220F RQ-4 UAV, Proj. #675145 Block 30, funded development activities including mission planning development and testing, Mode 5 Automatic Dependent Surveil-lance-Broadcast (ADS-B), enhanced weather capability development and testing, ice protection system development and testing, airspace and interoperability and communication enhancements and updates, airframe upgrades, sensor upgrades and integration of alternate sensors, risk reduction and integration, periodic Operation Flight Program updates and releases, and resolution of issues with Diminishing Manufacturing Sources (DMS). Work will include systems engineering/program management, configuration and data management, test and evaluation, management services, Deficiency Report/Materiel Improvement Project (DR/MIP) Investigations, studies and analysis and fielding support for Projects 675146 (Block 40), 675147 (Ground Segment/Comm System), and 675149 (Capability Enhancements).

FY15-17 will see continuing enhancement of the Enhanced Integrated Sensor Suite (EISS), including completion of Synthetic Aperture Ra-

dar (SAR)-Complex Imagery (CI) development, as well as Airborne Signals Intelligence Payload (ASIP) enhancements (Increment 1 development). Funding for these projects is substantial – perhaps half of totals of $140.3/$69.7/$93.4 million in FY15/16/17 (the USAF does not break out specific project funding).

Global Hawk Capability Enhancements RDT&E

In February 2016, the USAF planned the new RQ-4 Capability Enhancements program and funding line to begin in FY17 (PE# 0305220F RQ-4 UAV, Project #675149), in order to provide greater visibility into Global Hawk modernizations by consolidating the majority of the efforts from Project #675145 (Block 30), Project #675146 (Block 40), and Project #675147 (Ground Segment/Comm System). Activities will include airspace and interoperability and communication enhancements and updates, airframe upgrades, sensor upgrades and integration of alternate sensors, risk reduction and integration, ice protection system development and testing, program protection projects, cybersecurity, government furnished equipment repair, legacy data items (technical data packages), resolution of issues with DMS, periodic Operation Flight Program updates and releases, and additional sensor modes. This will include systems engineering/program management, configuration and data management, test and evaluation, management services, DR/MIP Investigations, studies and analysis and fielding support for Projects #675145, #675146, and #675147.

Activities will also include the GSMP, CSMP and the Next Generation Communication System. The RQ-4 program will maintain and upgrade interoperability for Blocks 20/30/40 with system of systems partners, and continue to incorporate applicable synergies with other platforms such as the U.S. Navy's Triton, other RPA weapon systems, and Transport, Processing, Exploitation & Dissemination (T-PED) elements. The networking capability for intelligence dissemination is required to provide the data transport interface between the Weapons System, Operations Centers, and external Intelligence Community customers.

When judged feasible and affordable, this program will participate in the development, testing, and implementation of international standards to enhance joint, allied, and coalition interoperability. Studies and activities may be initiated to further explore the utility of incorporating the emerging architectural standards such as the USAF Un-manned Aerial System (UAS) Command and Control Initiative (UCI) or the DoD's Unmanned Control Segment standards (UCS) and Open Mission Systems (OMS). GSMP and CSMP will incorporate UCI and UCS standards.

Eight Block 30M Upgrades for Global Hawks with ASIP

In March 2016, the USAF's Air Force Life Cycle Management Center, Wright-Patterson Air Force Base, OH, awarded Northrop Grumman Aerospace Systems, San Diego, CA, a $30.3 million contract modification to upgrade eight RQ-4 Block 30, Block I Global Hawks to the Block M (or "Block 30M") configuration, including upgrades to ASIP. The Block 30M carries ASIP along with the Raytheon EISS EO/IR and SAR/MTI sensor suite. Work will be conducted in San Die-go, CA, and should be finished by December 2017.

Fleet Status

In May 2017, the USAF active Global Hawk inventory consisted of four (4) Block 20s, eighteen (18) Block 30s, and eleven (11) Block 40s. Three (3) additional Block 30s were currently in production with scheduled deliveries beginning in 2017. The ground segment includes the Mission Control Element (MCE) and the Launch Recovery Element (LRE). There are a total of ten (10) active ground segments in the existing RQ-4 inventory. Two (2) additional production LREs were purchased in 2015. One was installed in Dec 2016, while the other is scheduled to install in May 2017.

The designed service life of the Block 30 Global Hawk air vehicles is approximately 25 years with an average service life remaining of 16 years – through 2032. The designed service life of the Block 40 RPAs is approximately 25 years with an average service life remaining of 18 years – through 2034. The designed service life of the ground segments is approximately 32 years with an average service life remaining of 18 years – through 2034.

U-2 to Serve Indefinitely Alongside Global Hawk

In May 2017, in the FY18 budget, U-2 operations and upgrade & support were extended indefinitely to continue operation alongside Global Hawk. The U-2 airframes are reportedly good to fly through 2045. Total planned funding through FY22 in the FY18 budget was $156.2 million RDT&E and $247.9 million procurement, up from $8.4 million and $34.1 million in the previous FY17 budget.

In mid-2017, according to Lockheed Martin, the U-2 was flying 3,500 sorties a year, with a 95% mission effectiveness rate.

Global Hawk Block 30 Sensor Upgrade RDT&E

In May 2017, USAF FY18 budget plans in PE# 0305220F RQ-4 UAV, Proj. #675145 Block 30 fund continuing upgrades from FY16-FY18 and beyond to the

Airborne Signals Intelligence Payload (ASIP) Signals Intelligence (SIGINT) sensors (including ASIP Increment 1 Development from FY16-FY18) and Enhanced Integrated Sensor Suite (EISS) sensors.

Global Hawk Crashes

In June 2017, a Global Hawk crashed in a remote area near Mount Whitney in California.

Global Hawk Shot Down by Russian S-300 SAM?

In June 2017, unsubstantiated claims were made that an EQ-4 "BACN" Global Hawk was shot down by a Russian S-300 SAM over the Mediterranean near Syria. The US Air Force has apparently dismissed the claim without comment, and there is no public indication that this is anything other than "fake news," perhaps sponsored by the Russians themselves. On the other hand, the EQ-4 is potentially vulnerable to just this sort of loss.

EISS Upgrade Contract to Raytheon

In August 2017, the USAF awarded Raytheon $25.9 million contract for modifications and retrofitting of sensors on the Block 30 Global Hawk, to cover engineering work for upgrades to the Enhanced Integrated Sensor Suite (EISS) and retrofitting of the Enhanced Electro-Optical Receiving Unit on Global Hawks. The work will be performed in El Segundo, CA, to be completed in February 2019. The Air Force obligated $16.6 million in 2017 funds upon contract award.

USAF Continues Plan to Keep Global Hawk for the Long Term

In February 2018, the USAF FY19 procurement budget stated the designed service life of the Block 30 Global Hawk is approximately 25 years with an average service life remaining of 14 years – through 2032. The designed service life of the Block 40 Global Hawk (MP-RTIP) is approximately 25 years with an average service life remaining of 16 years – through 2034. The USAF Global Hawk Program Office is exploring options to extend the service life.

In February 2018, the active inventory consisted of four (4) Block 20 Global Hawks which have been converted to Battlefield Airborne Communications Nodes (BACN), eighteen (18) Block 30s, and eleven (11) Block 40s. Two (2) additional Block 30s were currently in production with scheduled deliveries in 2018.

Global Hawk Sensor Upgrade New Starts

In February 2018, the USAF FY19 procurement budget outlined P-3A Mod 470020 ***EISS Enhancements*** – a new start in CY18 (Calendar Year).

In CY18, P-3A Mod 470021 ***ASIP Increment II*** was also a new start.

Delays to Korean, Japanese, NATO Global Hawk Deliveries

In April 2018, South Korea's arms agency announced a delay to the delivery of the first two RQ-4 Global Hawks – now planned for the first half of 2019 instead of the second half of 2018. The delay is so additional cybersecurity-related measures can be added, in order to "beef up the anti-hacking system," according to US sources.

The final two South Korean Global Hawks are still to be delivered in 2019.

A US Defense Acquisition Program Administration (DAPA) official also stated, "The delivery time for Japan and NATO has been put off by a year."

Second (or Third) Global Hawk Crashes

In June 2018, a USAF RQ-4 Global Hawk crashed (and was destroyed) in the waters off the coast of Spain, but the crash was not initially announced by the Air Force. This makes either the second loss of a Global Hawk in a year, when including the one that crashed in California in June 2017, or potentially the third, if counting the unsubstantiated claim that an EQ-4 "BACN" Global Hawk was shot down by a Russian S-300 SAM over the Mediterranean near Syria.

Note that there are not many of these aircraft to go around – they were not built with attrition in mind, as with the Predator and Reaper.

Recent History (Global Hawk Follow-On Sensors [EO/IR])

Congress Pushes U-2 Sensors for Global Hawk

In early 2015, FY16 budget documents reported a Congressional Add of $10 million in FY14 to fund a study for adaptation of U-2 Sensors for the RQ-4 Block 30. The study assessed the integration of U-2 sensors or alternative sensors of comparable capability onto the RQ-4B, including comparing how differences in flight performance would affect sensor performance (such as enhanced weather capabilities, and mission planning and airspace and sensor interoperability).

This Current Developments section focuses primarily on transferring upgraded U-2 sensors to Global Hawk, but also includes all-new sensors and upgrades envisioned for Global Hawk, now that its long-term future finally seems more assured.

U-2 Still Operating Near "Surge" Level

In mid-2016, USAF sources reportedly claimed the U-2 still gathered 70% of all Air Force high-altitude imagery.

Sources indicate the U-2 will continue in service for years, despite repeated attempts to retire the fleet early. In mid-2016, USAF sources claimed the U-2 was operating at 80% capacity, in constant service, near to a reported "surge" level.

Oops… That Metal Grid Doesn't Really Cost a Billion Dollars…

Well… we meant more like $100 million…. Later in 2015, a "closer examination" led the USAF and Northrop Grumman to reduce their cost estimates to develop the Block 30 Global Hawk's Universal Payload Adaptor (UPA). In March 2016, Northrop was awarded a contract to modify more Block 30 Global Hawks. However, not all information on the number of systems, or additional development costs, or exactly which sensors are included in the initial contracts, has been made public. Suffice to say, though now more

likely going ahead, the UPA will still be as expensive as Northrop Grumman can make it, with costs probably spread over the next decade or more.

MS-177 Trialed Aboard USAF Avenger

In early 2016, at least seven test flights were conducted by the USAF of the 538-lbs. UTC Aerospace Systems (UTAS) MS-177 multispectral sensor aboard their Predator C Avenger test air vehicle. Chris Pehrson, General Atomics' senior director of strategic development, said the tests went very well, looking at both land and maritime targets and testing integration and datalink software. On the Avenger, the MS-177 can pivot 20 degrees to allow a wider field of view; the MS-177 is essentially the follow-on sensor to the U-2's SYERS-2. According to the Air Force, there are no plans for more demonstrations on the Avenger

Instead, the primary goal of the test was to prove future sensor parity between the Global Hawk and the U-2 it is to replace – U-2 must continue in service until Global Hawk can adequately replace it's sensor capabilities (even if not carrying more than one sensor at a time as the U-2 can).

MS-177 Onboard Data Processing Tested

In early 2016, the USAF Predator C Avenger/MS-177 test flights also demonstrated improved onboard processing of multi-spectral imagery, to reduce downlink bandwidth. A low-resolution "macro-view" was sent to the ground station, with a ground request for specific high resolution "chip outs." UTAS sources reported that perhaps 2% of collected imagery "is really of interest in real time."

The U-2's wideband satcom link provides a 274 Mbps data link, which can just barely handle the new 10-band SYERS-2C sensor, according to UTAS. If other data are sent as well, the SYERS-2C feed is typically reduced to 6 or 8 or fewer bands downlinked. Reportedly, L-3 Communications is developing a 500 Mbps BLOS data link for the U-2.

U-2 to Global Hawk Sensor Transfer Funding

In February 2016, USAF FY17 budget plans funded RQ-4 Post-Production procurement, to support production line shutdown and disposition activities, Ground Segment Modernization Program (GSMP), sensor procurement and related activities, as well as technology insertion activities in support of Better Buying Power initiatives.

Funds will support sensor procurement to include, but be not limited to, the installation of two (2) Multi-Spectral (MS)-177 sensors, four (4) MS-177 Sensor Interface Modules (SIM), eight (8) Optical Bar Camera (OBC) SIMs, eighteen (18) sensor calibrations, and support related activities and other government costs.

According to the USAF in their FY17 budget documents, somehow, to make someone happy, "Neither the MS-177 nor the OBC are replacing systems currently flown on the RQ-4." Um, okay. Also in the budget is this statement: "Presently, there are no developmental test results as the Program Office only awarded a contract to integrate the MS-177 onto the RQ-4 at the beginning of FY16."

Additionally, funds will support Global Hawk costs to shut down the production line upon completion of the production phase. Post-production costs include production equipment disposition, contract closeout, sustaining engineering ramp down, mission support, production closeout costs, and other related costs.

Funding may be used to alleviate Diminishing Manufacturing Sources (DMS) issues for which there are not sufficient Government spares and/or the ability to repair organically or commercially is not viable.

Some Global Hawks to Have "HISAR" Removed for SYERS-2/MS-177

Although the U-2 ASARS-2 radar is not currently planned to be transferred to Global Hawk, Raytheon's legacy "HISAR" radar is planned to be removed from some Block 30 Global Hawks, to make room for the superior EO/IR systems based on U-2 systems – the SYERS-2 and MS-177 sensor suites.

UPA on Global Hawk: U-2 SYERS-2 Tested

By mid-2016, a Universal Payload Adaptor (UPA) had been mounted on a Global Hawk, with a 544 kg capacity, and the U-2's SYERS-2 system had reportedly been tested with the UPA.

OBC Testing Planned on Global Hawk

In mid-2016, Northrop Grumman planned to begin testing the UTC Aerospace Systems (UTAS) Optical Bar Camera (OBC) from the U-2 in August 2016, on a Global Hawk with the Universal Payload Adaptor. The wet-film OBC, despite its 20th century technological origins, has been "constantly tweaked… to provide higher-quality intel," according to US Air Force sources.

10-Band SYERS-2C Upgrade for U-2

By mid-2016, the U-2's SYERS-2 had already had two sets of upgrades in the past five years, including better data links and data access to ground troops, and improvements for maritime use.

In mid-2016, the upgraded SYERS-2C was being fielded with 10 spectral bands, an improvement from the 7 bands of the SYERS-2B, and now including real color, visible, and near-, shortwave, midwave, and longwave infrared (IR) bands. UTC Aerospace Systems (UTAS) also claims the SYERS-2C has higher resolution and longer range.

Another benefit of multi-spectral EO/IR is that the slightly different time differentials between the bands

can some-times be used to determine velocity of movement (such as with red and green bands). Sequential scans with all 10 bands can sometimes provide a short video (albeit a very data-intensive way to create a video).

The USAF reportedly plans to upgrade all U-2 SYERS-2B systems to -2C standard, with two operational and a third in flight test in June 2016, and "a few more on contract to upgrade," according to a Lockheed Martin (U-2) source. This indicates a total of about ten or fewer interchangeable SYERS systems for the 27-strong U-2 fleet, with a few at each of three U-2 operational sites.

MS-177: 2017 IOC on Global Hawk

However, in mid-2016, Air Force plans were still to retire the SYERS-2 – even the upgraded SYERS-2C – with the U-2, rather than transfer the systems to Global Hawk. Instead, the new UTAS MS-177 system is planned for integration on Global Hawk with the UPA at the end of 2016, with initial operating capability (IOC) in 2017 and full operating capability in 2019.

What this likely indicates is USAF expectations of continued U-2 service beyond 2019 – or else the SYERS-2C would be planned for transfer to Global Hawk, or would not have been upgraded.

Funding for MS-177 sensor integration onto Global Hawk is substantial – contracted directly with UTAS by the USAF, with $42.0/$40.4/$4.0 million in FY15/16/17.

SYERS-2C Upgrades Lead to Long Range MS-177 and Tac Recce MS-110

By mid-2016, UTC Aerospace Systems (UTAS) had used the technology from upgraded SYERS systems from the U-2 (SYERS-2C) and Global Hawk (MS-177) to develop an upgraded, multi-spectral MS-110 fighter tac recce system out of the dual-band DB-110 (the original DB-110 was a reduced focal length [110 inches…] podded export variant of the earlier SYERS-2A).

In mid-2016, UTAS reported the DB-110 system was in use by 13 countries.

Both the long-range MS-177 and tactical MS-110 were developed with UTAS company funding, and both will be offered in the future for US and foreign sales. The MS-177 and SYERS-2 both have 177-inch focal length optics for long range, but the SYERS-2 has a "whisk broom" sensor that only scans at 90-degrees to the path of the aircraft, from horizon to horizon, while the MS-177 (like the DB/MS-110) has a gimbaled sensor that adds a +/- 25 degrees fore-and-aft scan ability to the +/- 90 degrees lateral scan.

Currently, the MS-177 in testing has a 7-band sensor, but in 2017 the MS-177A version will use the upgraded 10-band sensor. UTAS claims the MS-177 is "modular" to allow easier upgrades, and also has "equivalent or better range" to the U-2's SYERS-2 with improvements to optics and the focal plane array, as well as company-funded onboard image processing upgrades.

The MS-110 will provide six or seven bands of imagery while using the same pod and ground stations as the DB-110. A UTAS source stated in June 2016, "We are accepting orders and building hardware…. Several customers have expressed interest in both new and refurbished pods…." – which seems to indicate there is not yet an actual production contract.

Now Lockheed Pushes for Global Hawk Sensors – For U-2: SYERS-3!

Proving how inter-related these manned and unmanned high altitude ISR platforms have become, in mid-2016 Lockheed Martin was hoping the MS-177's gimbaled sensor would eventually be added back into the U-2, to become "SYERS-3."

At the same time, Lockheed also hoped to persuade the USAF to relocate the current SYERS system from the U-2's nose to the Q-bay behind the pilot, which would allow carrying SYERS and the ASARS-2 radar simultaneously. Both are now carried in the nose, interchangeably, despite the U-2's much greater 5,000 lbs. payload compared to Global Hawk. Of course, if SYERS-3 could be carried in every U-2, that could also mean buying a dozen more new SYERS-3 sensors, to add to the dozen or so optional nose-SYERS systems today….

All of these options depend on whether the Air Force substantially extends the U-2's service life beyond 2019.

Global Hawk Open Mission System (OMS)

In 2016, the USAF's Global Hawk began testing several new (or borrowed from the U-2) sensors with the new Universal Payload Adaptor (UPA). The OMS is a C4I "wrapper" that "goes around" air vehicle software to allow new sensors and capabilities to be added more quickly – one of the few attempts to create a modular payload system that has even reached the testing stage. So far, since early 2016 the OMS has been used aboard Global Hawk to test the SYERS-2 EO/IR sensor on the UPA, with Optical Bar Camera (OBC) and MS-177 sensor tests planned for later in 2016.

In 2015, Lockheed Martin had used the OMS on its U-2 under Project Iguana, to integrate five different systems new to the U-2 in less than six months – three electronic attack systems, SYERS-2C, and a communications radio.

Universal Payload Adaptor Ready

Beginning in 2015, under a cooperative research and development agreement (CRADA) with the USAF, Northrop Grumman developed a universal payload adaptor that attaches to the underside of the Block 30 Global Hawk, allowing the carriage of new sensor payloads. Northrop claims it developed the payload adaptor and introduced an open mission system (OMS) software architecture to Global Hawk within 18 months under

the CRADA, at cost of $80 million, not the originally proposed $600 million.

10-Band MS-177A Development Contract for Global Hawk

In September 2016, UTC/UTAS (was Goodrich) announced that it had started development of an improved, 10-optical band MS-177A under an Air Force design contract. MS-177A system deliveries are to begin in 2019.

MS-177 Tested Aboard Global Hawk

In February 2017, Northrop Grumman began flight testing the UTC MS-177 multi-spectral long-range imaging sensor aboard Global Hawk, to be followed by operational testing. Northrop said it expects the USAF to make a decision on fielding by the end of 2017. In February 2016, Northrop flew the Senior Year Electro-optical Reconnaissance System-2 (SYERS-2) on Global Hawk, and more recently completed flight tests of the Optical Bar Camera broad-area synoptic sensor.

MS-177A Procurement: $94 Million for Two… Much More then "Advertised"

In May 2017, USAF RQ-4 Post-Production procurement funding will support Global Hawk production line shutdown and disposition activities, sensor procurement and related activities, Optical Bar Camera (OBC) Sensor Interface Modules (SIM) procurement, as well as technology insertion activities in support of Better Buying Power initiatives. RQ-4 sensor funding will support the total procurement and installation of two (2) MS-177A sensors, four (4) auxiliary equipment B-kits, support equipment, sensor calibration flights, training, data, Interim Contractor Support (ICS), and other costs to complete the fielding of the sensors. Fairings and sensor windows will also be procured in support of the sensors. The B-kits consist of the SIMs, airborne file servers, tooling, and other related equipment. Funds will also be utilized for the procurement of three (3) OBC SIMs.

According to the Air Force, "neither the MS-177 nor the OBC are replacing systems currently flown on the RQ-4." Presently, there are no developmental test results as the Program Office only awarded a contract to integrate the MS-177 onto the RQ-4 at the beginning of FY16.

In May 2017, USAF FY18 budget plans funding RQ-4 Post-Production procurement showed a unit cost of about $10-12 million each for two MS-177A sensors for Global Hawk in FY18 – but considerable additional contractor costs and support raised the total procurement cost to $67.4 million for two sensors, presumably installed. Initial spares added a further $27.0 million. The MS-177A is thus, perhaps, a deceptively expensive system….

The two MS-177As have a projected IOC of December 2017.

Global Hawk for Laser Missile Defense

In August 2017, Northrop Grumman announced plans to "modernize" Global Hawk for the US Missile Defense Agency's (MDA) proposed HALE UAV laser anti-missile system development program.

In June 2017, the MDA posted an RFI on the Federal Business Opportunities website for a HALE UAV equipped with a high-energy laser that can destroy an intercontinental ballistic missile (ICBM) in the boost phase. The RFI requires a HALE UAV with a minimum altitude of 63,000 ft and a payload capacity between 5,000-12,500 lbs (2,270-5,670 kg). The newest RQ-4 Global Hawk can reach 60,000 ft and can carry a 3,000 lbs payload, though Northrop Grumman officials reportedly have said the current configuration could potentially carry a maximum payload of 4,000 lbs.

The HALE program will follow on from MDA's current low-power laser demonstrator program, which is working to improve laser stability at long range, and to improve laser beam steering in order to dwell on a single spot on a target. A low-power laser flight test is scheduled for 2020, with beam stability evaluations planned for 2021. The MDA reportedly hopes to field a laser HALE around 2023 (which seems absurdly optimistic to Teal Group…).

Northrop is looking to work with the USAF and MDA to reduce the RQ-4's weight and increase its maximum altitude, according to Mike Lyons, in charge of Northrop's Global Hawk business development. Lyons said Northrop is "not pursuing exotic solutions" to save weight, but rather recent commercial developments. Northrop will remove some legacy equipment and systems (still there from the late 1990s) from the RQ-4 which might be replaced with newer, lighter, potentially commercial systems.

Lyons also discussed the difficulties in developing a precision airborne laser, agreeing with the MDA in seeing beam steering and stability as a primary challenge. Northrop is currently integrating three new long-range U-2 sensors aboard the Global Hawk – UTC's MS-177 and Senior Year Electro-Optical Reconnaissance System-2 (SYERS-2), and the Optical Bar Camera. Lyons said, "All three are extremely vibration sensitive…. Our pointing accuracy [has been validated as] exceptionally good… it's right in the center of gravity and it maintains very low vibrations."

Northrop Grumman also led the earlier USAF Airborne Laser (ABL) program, which mounted a large chemical laser payload on a Boeing 747. More recently, in August 2016 the USAF Air Force Research Laboratory (AFRL) awarded Northrop Grumman a $39.3 million, five-year contract for development efforts as part of the STRAFE (SHiELD [Self-protect High Energy Laser Demonstrator] Turret Research in Aero-efFEcts) Advanced Technology Demonstration (ATD) program, for a laser-based self-defense DIRCM system for pod-mounting on fast jets.

Northrop rightly claims to have both legacy and recent experience for the MDA program.

UTC to Acquire Rockwell Collins for $30 Billion; UTAS to Become Collins Aerospace Systems

In September 2017, United Technologies Corp. (UTC) and Rockwell Collins, Inc. announced a definitive agreement under which UTC will acquire Rockwell Collins for $140.00 per share, in cash and UTC stock. According to their press release, "Rockwell Collins is a leader in aviation and high-integrity solutions for commercial and military customers and is globally recognized for its leading-edge avionics, flight controls, aircraft interior and data connectivity solutions. On a 2017 pro forma basis, its estimated sales are greater than $8 billion."

The transaction is projected to close by 3Q 2018. The purchase price implies a total equity value of $23 billion and a total transaction value of $30 billion, including Rockwell Collins' net debt. On a pro-forma 2017 basis, UTC is expected to have global sales of approximately $67 to $68 billion following the transaction. UTC announced it expects the combination generate an estimated $500+ million of run-rate pre-tax cost synergies by year four.

Upon completion of the transaction, Rockwell Collins and UTC Aerospace Systems will be integrated to create a new business unit named Collins Aerospace Systems. Kelly Ortberg will assume the role of Chief Executive Officer with Dave Gitlin serving as President and Chief Operating Officer.

A Quarter Billion $ to UTAS for MS-177 & MS-177A RDT&E Funding

In February 2018, in the USAF FY19 budget, PE# 0305220F RQ-4 UAV, Proj. #675149 RQ-4 Capability Enhancements, funded RQ-4 MS-177 Sensor Integration RDT&E plans from FY17 forward – transferring development and funding from Proj. #675145 RQ-4 Block 30 RQ-4 (funded through FY17).

FY18 Plans: Continue integration and testing of MS-177 on Block 30, including additional spectral bands; Conduct MS-177 OT and Initial Operational Capability (IOC); Continue development of MS-177A (10-Band).

FY19 Plans: Continue integration and testing of MS-177 on Block 30, including additional spectral bands; Conduct MS-177 OT and attain IOC; Continue development of MS-177A (10-Band) and integration; Begin DT of MS-177A.

In February 2018, target value of the MS-177 contract was $122.3 million of funding in Proj. 675145 and $142.5 million in Proj. #675149, contracted directly with UTAS.

MS-177 & MS-177A Test Status

By June 2018, the first baseline 7-band MS-177 had been delivered by UTAS for operational testing on Global Hawk.

In June 2018, UTAS announced the first MS-177 upgraded to the 10-band A-model configuration would begin flight trials by the end of 2018. Flight tests on Global Hawk will begin after late 2019.

Recent History (Global Hawk Follow-On Sensors [Radar])

U-2 ASARS-2B Development

In mid-2016, Raytheon was developing a major ASARS radar upgrade for the U-2. While one of the few U-2 sensors not currently planned to eventually be "transitioned" to Global Hawk, as a nose-mounted sensor on the U-2 – like the SYERS-2 EO/IR sensor already tested on Global Hawk – ASARS or a version of ASARS (as indeed the radar in the EISS is…) could eventually serve on Global Hawk or another UAV.

According to Lockheed Martin (U-2 prime/integrator), the new "deep look high altitude" ASARS-2B will add an active electronically-scanned array (AESA) radar that would double the range and enable concurrent SAR imaging and GMTI (ground moving target indication), allowing a wide-area sweep, location of moving objects, and high-resolution imaging.

Despite plans to retire the U-2 in 2019, a substantial amount of USAF ASARS-2B funding is planned to continue into FY19 and beyond. In the February 2016 FY17 budget, ASARS-2B Tech Maturation was planned and funded from 1QFY17-2QFY19.

Some Global Hawks to Have "HISAR" Removed for SYERS-2/MS-177

Although the U-2 ASARS-2 radar is not currently planned to be transferred to Global Hawk, Raytheon's legacy "HISAR" radar is planned to be removed from some Block 30 Global Hawks, to make room for the superior EO/IR systems based on U-2 systems – the SYERS-2 and MS-177 sensor suites.

C-ABSAA Funding Shifted from Global Hawk Program

In February 2018, the USAF FY19 budget stated in PE# 0305220F RQ-4 UAV, that per direction of USD (AT&L), the RQ-4 program had been restructured from the original project #675144 (Baseline) into multiple projects: (1) Block 30, (2) Block 40, (3) Ground Segment/Communications System, and (4) Common-Airborne Sense and Avoid (C-ABSAA). In FY17, the Ground Segment/Communications System project (#675147) ended.

In February 2018, the primary C-ABSAA RDT&E funding line had been moved to PE# 0604257F Advanced Technology and Sensors, Proj. #645148 Common-Airborne Sense and Avoid (C-ABSAA). Planned USAF funding in Proj.

#645148 is about $20 million per year from FY18-FY20, and about $40 million per year from FY21-FY23.

In February 2018, the USAF described C-ABSAA as an analysis development, maturation and transition effort in the Materiel Solu-tions Analysis phase of the acquisition lifecycle which supports emerging warfighter requirements to fully integrate Group 4-5 Remotely Piloted Aircraft (RPA) into the National Airspace System (NAS), international airspace, other nations' sovereign airspace, and operational combat airspace to conduct the entire range of military operations across all mission environments.

C-ABSAA also supports the "Worldwide Operations" key performance parameter in larger RPA requirement documents, and Public Law 112-239 directing DoD collaboration with the Federal Aviation Administration (FAA) and the National Air and Space Administration (NASA) to safely integrate RPA in the NAS. Funding in this project (#645148) supports the development of a Sense and Avoid (SAA) capability set for Group 4-5 RPA and covers analysis, research, developmental, demonstration, and transition activities as well as infrastructure and other government costs.

Ongoing activities include support to the development of warfighter requirements and analysis of possible solution alternatives, collaboration with the FAA, NASA, and the other Services to develop national policy and standards, and SAA related studies, analysis, modeling and simulation, flight demonstrations of critical technologies, and program transition planning and project execution. RPA platform specific integration and testing is not included.

Activities also include studies and analysis to support both current and future program planning and execution. This program element may include necessary civilian pay expenses required to manage, execute, and deliver technology and sensor capability. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0605826F, 0605827F, 0605828F, 0605829F, 0605830F, 0605831F, 0605832F, and 0605898F.

C-ABSAA RDT&E Plans

In February 2018, funding in PE# 0604257F, Proj. #645148 provides for the following RDT&E developments:

FY18 Plans: Complete C-ABSAA Materiel Solution Analysis activities; Begin C-ABSAA Technology Maturation & Risk Reduction Phase; Support development of Capabilities Development Document and System Requirements Document/Technical Requirements Document; Prepare/present all documentation/results as part of C-ABSAA Milestone A decision review; Continue to build and exercise modeling and simulation capabilities to support requirements analysis, cost/capability trades, policy/standards development, and technology maturation and availability evaluation; Continue SAA science and technology research and development with AFRL for future planning and development; Continue to collaborate with FAA, NASA, and other Services and agencies on national policy and standards; Begin design/development of open modular architecture to minimize A/C integration costs and facilitate capability upgrades.

FY19 Base Plans: Continue C-ABSAA Technology Maturation & Risk Reduction Phase; Support validation of CDD and System Re-quirements Document/Technical Requirements Document; Prepare/present all documentation/results as part of C-ABSAA Milestone B decision review; Continue to collaborate with FAA, NASA, and other Services and agencies on national policy and standards; Continue development/test/certification of open modular architecture.

C-ABSAA Acquisition Strategy

In February 2018, USAF C-ABSAA Acquisition Strategy in PE# 0604257F, Proj. #645148 planned for C-ABSAA materiel solutions to be developed by the Air Force Life Cycle Management Center's Sensors Program Office under direction of the Program Executive Office for Intelligence, Surveillance, and Reconnaissance and Special Operations Forces, in response to a deliberate requirements definition process. C-ABSAA will integrate applicable Better Buying Power 3.0 initiatives throughout its acquisition lifecycle and rely upon acquisition of government data rights to maximize contractor competition from technology development through production. The program intends to provide the warfighter with platform independent sense and avoid capability for Group 4-5 RPA through increased, time-phased capability improvements as technology and risks achieve satisfactory levels. Group 4-5 RPA platforms will be expected to integrate C-ABSAA capability into their unique systems either via retrofit or in design, development, and/or production.

C-ABSAA Planned Schedule

In February 2018, in PE# 0604257F, C-ABSAA Analysis of Alternatives was planned for 2QFY17-2QFY18; Materiel Solution Analysis from 2QFY17-2QFY18; Capability Development Document from 1QFY17-4QFY19; Milestone A in 2QFY18 (March 2018); Technology Maturation and Risk Reduction from 2QFY18-1QFY22; Milestone B in 1QFY22; and Engineering and Manufacturing Development from 1QFY22-2QFY23.

Recent History (Triton)

Navy SAA Radar Delayed for Triton

The MQ-4C has been decoupled from the first iteration of the SAA radar that was intended (and required) to be mounted on all Navy Tritons. The Air-to-Air Radar Sub-System (AARSS) had been in development by Exelis/ITT since 2009, but radar delays would have slowed platform introduction. Instead, for the moment, ship and ground-based radars will handle air traffic deconfliction and collision avoidance – the need for which will necessarily limit Triton operations.

In early 2016, according to Navy sources, the Navy had determined that, "there were still no alternate solutions" to a Triton-mounted radar that would meet full SAA requirements. The Navy "intends to field a viable SAA solution that includes an air-to-air radar for Triton by FY20."

India Opts for Less Expensive General Atomics Guardian UAV, not Silver-Bullet Triton

Despite earlier Northrop hopes that India's purchase of Boeing's P-8I Poseidon maritime patrol aircraft would lead to a Triton buy – the P-8 is Triton's partner for the US and Australian Navies' BAMS concept of maritime operation – India seems to be opting for the less expensive General Atomics Guardian UAV, a maritime variant of the Predator B Reaper, already in service with the US Customs and Border Patrol (CBP) and possibly the US Coast Guard.

In June 2016, India's Ministry of Defence (MoD) issued a letter of request (LoR) to the United States to procure 22 Guardian UAVs for the Indian Navy (IN) through Foreign Military Sales (FMS). The request closely followed India's induction into the 35-nation Missile Technology Control Regime (MTCR), also in June, which would allow the acquisition of armed UAVs.

Indian sources said a letter of acceptance from the US is expected later in the 2016, after which price negotiations would begin and a contract would be signed sometime in 2017-18. It is still uncertain, whether the IN will acquire the weaponized or non-weaponized Guardian variant, or both. Sources have suggested India might also acquire more than 22 UAVs, in a program estimated to be worth $2 billion or more.

In addition to joining the MTCR, in June 2016 India also acquired "Major Defense Partner" status with the US, presumably allowing access to US technology at a level similar to Washington's closest allies.

Indian sources claim the Guardian UAV would primarily aid India's maritime surveillance capabilities in the Indian Ocean region – a key new American objective in the Asia-Pacific region, in order to track Chinese ship movements as they transit to Africa. However, some fear the armed drones might be used by India in their conflicts with Pakistan.

Other Indian sources indicated an approval of the sale (though not the contract, which history shows could takes years to complete…) might occur before President Obama leaves the White House in January 2017, as an element in his "Pivot to Asia" strategy.

Australian Triton Schedule Uncertain

Over the next decade, Australia is planning to acquire seven MQ-4C Triton maritime UAVs, to operate with between eight and 12 manned P-8A Poseidons. Together, they'll replace the RAAF's 18 AP-3C Orions. By August 2016, the 2016 Defence White Paper had reaffirmed Australia's plans to acquire seven Tritons for around A$3 billion, but developmental testing must be conducted before production begins. The current best estimate is for production to begin soon after 2020.

Triton LRIP – Finally?

In September 2016, the Navy's MQ-4C Triton received Milestone C Low-Rate Initial Production (LRIP) approval after a successful Milestone Decision Authority review. Triton successfully completed an operational assessment in February. The first Navy Triton is to be deployed in 2017, with two LRIP aircraft funded in FY17 and IOC planned for 2018. The Navy still plans to acquire 68 platforms plus two test aircraft, to maintain five 4-aircraft "orbits" in operation glob-ally.

Teal Group would be more impressed, and more inclined to both celebrate and compliment Northrop on a Triton program that has largely stayed on schedule and on budget – except for the fact that Triton is essentially a Global Hawk, which first flew in 1998 and has been in production for the USAF for years – and years ago had production truncated due to delays and cost overruns.

Germany Approves Triton SIGINT Buy with 2025 IOC

In March 2017, the German chief of defence staff General Volker Wieker approved the procurement of the MQ-4C Triton to meet the country's airborne SIGINT requirements, with the Airbus Defence and Space Integrated Signal Intelligence System (ISIS) mission system (originally planned for the cancelled Euro Hawk) as the payload. The planned procurement of three Triton/ISIS UAVs will give the Bundeswehr an airborne signals collection system for wide area surveillance and reconnaissance starting around the middle of next decade – planned IOC in 2025 – filling the gap in the Bundeswehr's capabilities that has existed since the manned Breguet Atlantic BR 1150 SIGINT aircraft was retired from service in 2010.

Reports indicate about €600 Million (including €270 Million for ISIS development) have been spent up to 2016. Assuming no overruns, the additional cost of the program (including three Tritons and additional ISIS/Euro Hawk testing) will be an-

other €900+ Million, with an IOC of 2025 – ten years later than the Euro Hawk planned IOC of 2015.

US Navy MQ-4C Triton Mission (2017)

According to the US Navy in May 2017, the MQ-4C Triton features sensors designed to provide near worldwide coverage through a network of five orbits inside and outside continental United States, with sufficient air vehicles to remain airborne for 24 hours a day, 7 days a week, out to ranges of 2,000 nautical miles. Onboard sensors will provide detection, classification, tracking, and identification of maritime targets and include maritime radar, electro-optical/infrared, and Electronic Support Measures systems. Additionally, the MQ-4C will have a communications relay capability designed to link dispersed forces in the theater of operations and serve as a node in the Navy's FORCEnet strategy. Tactical-level data analysis will occur in real-time at shore-based mission control sites connected to the air vehicle via satellite communications. Further intelligence exploitation can be conducted at Fleet shore-based sites or aboard aircraft carriers and other ships.

The MQ-4C Triton UAS will implement phased capability upgrades within the ongoing acquisition program to pace capability with rapidly evolving technologies and threats, to ensure the Navy maintains persistent ISR dominance through the system's lifecycle, and to support the Intelligence, Surveillance, Reconnaissance and Targeting transition plan. System upgrades will include Multi-Intelligence capabilities, Counter Electronic Attack upgrades, a more robust electronic support capability, and continue improvements to baseline mission system payloads.

MQ-4C will play a significant role in the Sea Shield and FORCEnet pillars of Sea Power 21. In its Sea Shield role, the system will rely on its key attribute of persistence to provide the supported combatant command or fleet commander with unparalleled situational awareness of the maritime battle space as it develops and sustains the common operational tactical picture. The system will also serve as a Fleet response plan enabler, while acting as a trip wire for intelligence preparation of the environment. Additionally, the Triton Unmanned Air System will be a FORCEnet enabler and relay platform, directly connected to both the Global Information Grid and the Distributed Common Ground System-Navy information backbone.

Triton Program Changes (2017)

In May 2017, the US Navy reported the Triton program was revised to align key program events and funding ($62.5 million) with the development of the Multi-INT capability upgrade in order to continue to support the Maritime Intelligence, Surveillance, Reconnaissance, and Targeting (MISR&T) Transition Plan. Key Performance Parameters and Key System Attributes were not affected, and capabilities essential to FY11 National Defense Authorization Act compliance are prioritized. To preserve the MISR&T transition plan, the Navy is prioritizing remaining work and adjusting the Triton fielding plan by:

- 1) Truncating the Triton Baseline program to deliver a safe, stable, and effective system that establishes the foundation for Triton Multi-INT development; and provides an early operational capability to facilitate Fleet introduction and learning in FY18.
- 2) Retrofitting low-rate initial production (LRIP) lot 1 and 2 air vehicles (Baseline) to a Multi-INT configuration upon delivery. Retrofit of LRIP lot 1 and 2 increases Triton Multi-INT capacity from three to five air vehicles by the end of FY20.
- 3) Deploying a Triton Multi-INT early operational capability in FY20.
- 4) Deferring initial operational test and evaluation (IOT&E) and initial operational capability (IOC) to the Multi-INT configuration in FY20/21.

SIGINT Additions for Multi-INT

The MQ-4C Triton acquisition approach supports the Navy's Maritime Intelligence, Surveillance, Reconnaissance, and Targeting (MISR&T) Transition Plan by providing a stable and effective baseline early operational capability in FY18 to facilitate Fleet introduction and learning, while continuing System Development and Demonstration engineering and integrated test on Signals Intelligence (SIGINT) and other upgrades to deliver a Multi-INT configuration at Initial Operational Capability (IOC). Phased capability upgrades will continue post IOC to enable the MQ-4C Triton to keep pace with rapidly evolving technologies and threats, and address correction of deficiencies and obsolescence issues to ensure the Navy maintains persistent Intelligence, Surveillance and Reconnaissance dominance through the system's lifecycle.

In the May 2017 US Navy budget, Sierra Nevada Corporation, Beaver Creek, OH (High Band Sensor kits) and Boeing Argon ST, Fairfax, VA (Low Band Sensor kits) were funded through FY17 for Primary Hardware Development, but planned funding ended in FY17.

Evaluation: Navy Fibs a Big One, and Provides More Evidence for a Classified Dedicated-SIGINT Triton

In early 2017, Sean Burke, the Naval Air System Command's Triton program manager, reportedly claimed the Pentagon's approval of the High and Low Band Sensors for Triton (with IOC planned for FY21) would enable the Navy to retire its EP-3E Aries II SIGINT aircraft – implying that the little bitty sensors on Triton (carried along with the MFAS radar and the EO/IR sensor) could somehow replace the thousands of pounds of modern sensors aboard the four-en-

gine Orion-based EP-3. Um… unlikely. As an indication of the continuing importance and sophistication of the EP-3, recent "Prior Years" Navy procurement funding for the small fleet stood at more than $1.3 billion as of May 2017, with $127.4 million spent in FY12 and more than $48.1 million spent in FY16 – meaning the EP-3 has large, complex, still-cutting edge SIGINT sensors. And this is just the "procurement tail" funding. Research and Development is funded with (classified) National Security Agency (NSA) Military Intelligence Program (MIP) funds – indicating the obvious source for classified Triton SIGINT RDT&E.

Burke also reportedly said, "Triton does similar things to what the EP-3 can do – similar profiles, CONOPS [Concepts of Operations], so it's kind of a logical transition." Um… not really. A high-altitude, long-endurance, multi-INT UAV focused on its primary MFAS radar (and which is still not cleared for operations over most populated land areas) does not fly the same profile as the lower-altitude, shorter endurance, manned (with a full operations crew for processing SIGINT in real time onboard) EP-3, which has seen much service recently over land. Not hardly.

Rather, this sounds like an obvious deception to provide some confusion over the dedicated, all-SIGINT Triton likely in development for the US Navy as a classified program – remember, Germany just contracted for three of its own all-SIGINT Tritons – which would indeed try to take over some EP-3 missions (though still with a much smaller payload and no in-the-air C4I from a big manned operations crew).

The first two Tritons are to be delivered to the Navy in FY18 with only the maritime reconnaissance capability (MFAS and EO/IR), to be followed three years later by the SIGINT/Multi-INT IOC.

Teal Group has no doubt that small Low and High Band SIGINT sensors aboard a multi-INT Triton would provide a useful capability – if in fact they exist at all. Designers don't usually leave empty space for unplanned future sensors, especially aboard an aircraft as tightly-packed and low-payload as Global Hawk/Triton. This is why the U-2 is still flying – because the Global Hawk does not have the payload to replace U-2 sensor capabilities. How even a dedicated-SIGINT Triton can replace the EP-3 – which is much bigger than a U-2 – is a big question, and Teal Group suspects many in the Navy are as concerned about the loss of capability as the Air Force was at every proposed U-2 retirement (each time cancelled). But the suggestion that dinky, retro-fitted SIGINT sensors jammed into corners can replace the glory that is an Orion-based EP-3 is just plain silly.

Triton RDT&E Projects

In May 2017, the US Navy budget showed funding from FY16 onward providing for Sense and Avoid radar development, Airborne Mission Processor (AMP) development, and acquisition of development assets for capability upgrades including electro-optical/infra-red (EO/IR), and SIGINT High Band and SIGINT Low Band systems.

Triton AARSS Radar Cancelled?

By 2018, there was no longer a major Triton airborne sense-and-avoid (ABSAA) Program of Record, with Triton instead now included in the overarching US Air Force Common C-ABSAA program. In August 2012, ITT Exelis (now Harris Corp.) exhibited its ABSAA radar then in development for the BAMS MQ-4C Triton, also known as the Air-to-Air Radar Sub-System (AARSS) – reportedly the first US DoD ABSAA radar program of record.

Four Tritons for Germany

In April 2018, the US Defense Security Cooperation Agency (DSCA) notified Congress of a $2.5 billion potential foreign military sale (FMS) of four MQ-4C Tritons to Germany, along with one mission control station with a main operating base and forward operating base, and 10 Kearfott Inertial Navigation System/Global Position Systems. "The proposed sale of the MQ-4C Triton will close a crucial capability gap and will enhance bilateral and NATO interoperability and will help ensure that Germany is able to continue to monitor and deter regional threats," the DSCA said in the statement.

Germany hopes to conclude contracts in 2019 and introduce the "Pegasus" (Persistent German Airborne Surveillance System) in 2025.

Australia Confirms Buy of Six – Not Seven – Tritons

In June 2018, the Australian government confirmed that it would acquire six MQ-4C Tritons, at an initial cost of just over USD $1 billion (but ultimately almost USD $5 billion). The first will enter service in 2023, with full operating capability to follow in late 2025, when all six have been delivered.

US Navy Gets First Baseline Tritons…

In June 2018, the US Navy received its first two MQ-4C Tritons, to be operated from Anderson Air Force Base on Guam beginning in late 2018. These first baseline standard Tritons carry Northrop Grumman's AN/ZPY-3 radar and Raytheon's EO/IR Multispectral Targeting System (MTS), a marine automatic identification system, and an ELINT sensor. Later deliveries will include a COMINT sensor and a sense-and-avoid radar.

Triton MTS Engineering Support Contract

In August 2018, Raytheon received a $9.4 million order for engineering support of the Triton MTS EO/IR system, with work to be performed in McKinney, TX and completed by August 2020.

… and First US Navy Triton Crashes

In September 2018, one of two US MQ-4C Tritons crashed on a Naval Base Ventura County (NBVC), CA

base runway following an "inflight mechanical issue" and landing gear failure. The pilots shut down the engine and attempted to land the aircraft on a runway at the naval base as a "precautionary measure." However, the MQ-4C's landing gear did not deploy.

Current Developments (Global Hawk)

US Navy BAMS-D Global Hawk Shot Down by Iran

In June 2019, Iran reported they had shot down a US Global Hawk flying near the Straits of Hormuz in the Gulf of Oman. Iran reported the UAV was flying over Iranian territory, which the US denied. Later, the US confirmed the UAV shot down was a US Navy BAM-D version – an earlier precursor to the new Navy MQ-4C Triton. The UAV was reportedly flying at high altitude, and Iran claims it was shot down by a *Raad* (Thunder) air defense system, a road-mobile, medium-range SAM system similar to Russia's SA-11 Buk SAM system.

$4.8 Billion Global Hawk Contract for Northrop Grumman

In October 2019, the US Air Force issued a presolicitation for a $4.8 billion ceiling sole source award to Northrop Grumman to modernize, retrofit, and produce all variants of the Global Hawk, under a "Global Hawk EPIC II" indefinite delivery/indefinite quantity (ID/IQ) contract. The presolicitation does not specify if new Global Hawks will be produced. The likely ordering period for the contract will extend from FY21 through FY25, with a full period of performance ending in FY30.

Current Developments (Global Hawk Follow-On Sensors [EO/IR])

United Technologies (Goodrich) Completes Acquisition of Rockwell Collins

In November 2018, United Technologies announced the completion of its Rockwell Collins acquisition, after which it merged its newly acquired business with UTC Aerospace Systems to form Collins Aerospace. The new company reported $23 billion of combined sales in 2017 and is composed of 70,000 employees.

MS-177 10-Band Contract

In February 2019, the Air Force reported that a contract for the MS-177A 10-Band was awarded in late FY18.

MS-177 7-Band DT Complete

In February 2019, the Air Force reported that 7-Band DT was complete, with OUE scheduled to start mid FY19.

Teal Group Evaluation

RQ-4B Global Hawk

Global Hawk Here to Stay

In February 2015, after several attempts to retire the Global Hawk Block 30, the US Air Force included Global Hawk in its FY16 budget, roughly equivalent to the March 2014 budget, providing some stability to what had become a changed-every-budget program. The Air Force had wanted to retire the Global Hawk and keep the U-2, but pressure from congressional allies of Northrop Grumman was reportedly a major contributor to keeping Global Hawk in service.

The Air Force then planned to retire the U-2 instead, in 2019, allowing time for upgrades to better prepare Global Hawk for the takeover. However, the Air Force threatened that if Budget Control Act funding cuts returned, the U-2 would be divested in 2016.

According to Northrop Grumman, Global Hawk cost per flying hour had halved in the past two years, which would mean it had gone from being more expensive and less capable to being cheaper, though still smaller and slower than the U-2. Speed matters for getting to distant mission areas, so Global Hawk's longer total endurance does not necessarily mean longer endurance over targets. The U-2 also has a considerably faster reaction time for urgent, pop-up, or fast-happening ISR needs. In the era of the (pretty slow) JSF, mentions of speed have largely disappeared from the USAF vocabulary, but U-2s and fighter tac recce still provide an important immediacy versus today's much slower Global Hawk.

By the FY17 budget in February 2016, Global Hawk was still solid and the U-2 was still theoretically planned for retirement in 2019, but major new Global Hawk upgrade funding had been added to out-years budgets. And U-2 upgrade funding had also been added – clearly too much for if the U-2 were to really be retired in 2019.

Finally, in May 2017 in the FY18 budget, the deception and posturing ended (at least for the moment), when U-2 operations and upgrade & support were extended indefinitely to continue operation alongside Global Hawk. The U-2 airframes are reportedly good to fly through 2045. Total planned funding through FY22 in the FY18 budget was $156.2 million

RDT&E and $247.9 million procurement, up from $8.4 million and $34.1 million in the previous FY17 budget. In mid-2017, according to Lockheed Martin, the U-2 was flying 3,500 sorties a year, with a 95% mission effectiveness rate.

In February 2018, the USAF FY19 procurement budget stated the designed service life of the Block 30 Global Hawk is approximately 25 years with an average service life remaining of 14 years – through 2032. The designed service life of the Block 40 Global Hawk (MP-RTIP) is approximately 25 years with an average service life remaining of 16 years – through 2034. The USAF Global Hawk Program Office is exploring options to extend the service life.

Thus, Global Hawk and U-2 now look likely to continue as the USAF's primary high-altitude, permissive-environment ISR platforms, with major upgrades that could continue for one or two decades – for both Global Hawk and U-2. U-2 funding is not as definite as Global Hawk now seems, and U-2 will likely remain on political tenterhooks – perhaps indefinitely – but for the next decade at least, it should continue to provide a necessary service alongside Global Hawk. By the middle of next decade, Global Hawk may have been upgraded enough, and there may be enough new (classified) stealthy ISR aircraft flying, to finally retire the U-2. But until then, major funding should continue for both platforms.

Global Hawk EISS Forecast

Regarding Raytheon's Enhanced Integrated Sensor Suite (EISS), by 2016 (and continuing today), U-2 and Global Hawk sensors were converging – the best U-2 sensors will now begin to transition to Global Hawk over the next few years, and substantial Global Hawk upgrade funding may result in improvements that then transfer back to U-2…. We have added a new section and forecast for USAF Global Hawk Follow-On EO/IR Sensors, which adds considerable information on these transitioning U-2 sensors.

This also means the EISS will probably begin to be retired on some Global Hawks, fairly soon. But a full replacement is unlikely, at least in the near term, and upgrades and support for EISS systems will continue. In fact, production of new EISS systems will continue into the next decade, recently for the three final USAF Block 30 Global Hawks, and for the first FMS Global Hawk buys, for South Korea and Japan.

Teal Group previously forecast that either Japan or South Korea, or both, would have an urgent enough need to buy a few Raytheon EISS suites without investing the time for a full-blown new sensor competition and development program. This seems to have occurred, and there could even be a few more EISS sensor suites produced (which we have not yet included in our production forecasts).

But beyond these near-term Block 30 Global Hawk EISS buys, and upgraded U-2 sensor systems for legacy USAF Block 30s (mostly developed and to be produced by UTC Aerospace Systems/UTAS [was Goodrich] without new competitions), future HALE sensor suite buys will certainly be built for additional Global Hawk/Triton production, or for other future HALE UAVs. Raytheon will not have a lock on production with its expensive and none-too-lauded EISS. In fact, UTC seems to have firmly taken over for near-term high-altitude EO/IR (something at which Raytheon has never really excelled).

MQ-4C Triton

Triton/BAMS/MFAS Program

In April 2008, Northrop Grumman won the $1.2 billion BAMS (Broad Area Maritime Surveillance) unmanned aircraft system (UAS) SDD contract, following years of program delays, with a modified Global Hawk. But due to the different maritime mission of BAMS, Northrop Grumman has developed a new surveillance radar, the AN/ZPY-3 Multi-Function Active Sensor (MFAS) active electronically-scanned array (AESA) SAR/ISAR. The maritime MQ-4C Triton UAV will place relatively less emphasis on the EO/IR sensor than the USAF Global Hawk.

By mid-2012, the Navy planned to acquire 68 MQ-4Cs, to maintain a standing operational fleet of multiple five-aircraft "orbits". However, Teal Group saw considerable scope for a reduced buy – and reductions seemed to begin in February 2015. Sixty-eight or even sixty-one aircraft may not be needed – despite "attrition and depot maintenance requirements" – and out-years procurement and O&M budgets would do better with fewer aircraft. The Air Force has capped its Global Hawks at about 20 Block 30s and 11 Block 40s.

On the other hand, oceans are big… and the whole point of BAMS is for Triton to provide an extremely wide, persistent surveillance area. More UAVs may be needed than by the Air Force for its more targeted reconnaissance missions. Final Triton fleet size will not be known for a decade, at least, even assuming initial production and IOC go ahead on schedule in the next few years.

In June 2018, the US Navy received its first two MQ-4C Tritons, to be operated from Anderson Air Force Base on Guam beginning in late 2018. But in September 2018, one of these two Tritons crashed on a Naval Base Ventura County (NBVC), CA base runway following an "inflight mechanical issue" and landing gear failure.

US Navy Triton/MFAS Numbers

One looming possibility throughout development has been a severely reduced or cancelled buy, especially during the recent years when the entire USAF Global Hawk was to be

grounded due to expense and lack of capability. With 100+ brand-new P-8A Poseidon manned maritime patrol aircraft now well into production, Triton is important but also expensive. The P-8A is vital, quite a cost bargain, and already performing very well. Triton has had the Global Hawk legacy to contend with – 20+ years of missed deadlines, and two reduced or cancelled USAF programs – truncated Block 40 production and suggested divestment, and the Air Force's 2012-2014 attempts to mothball its Block 30s.

With billions of dollars (and we mean tens of billions) in any realistic life-cycle cost estimate for 68 Tritons, many Navy budgeteers would love to just write that off, or at least half of it, which would still give a fleet equal in size to the Air Force's Global Hawks. In 2013, we forecast minor Triton development delays, and in March 2014 the Navy again obliged with a one+ year delay to all testing and production schedules.

But the February 2015 Navy budget largely held the previously-delayed schedule, and the February 2016 budget added substantial early production funding. US Navy Triton LRIP was approved in September 2016. We have thus – and this rarely happens – moved our production forecasts to the *left* over the past three years. We usually expect increased delays every year, but Triton seemed to be holding. Perhaps learning from Global Hawk, Northrop Grumman has not promised unrealistically rapid development of Triton. We commented on this a few years ago, and the conservative plans have held much better than any previous USAF Global Hawk schedules.

Regarding total US Navy numbers, at least a USAF-sized fleet of Tritons – about 30 UAVs – now looks fairly secure, and at least that number will be necessary to work with the Navy's large fleet of new P-8 manned maritime patrol aircraft to fulfill the Navy's global strategy. But if production of 30 Tritons is not complete until the middle of next decade – as planned – any number of things can happen, from a new non-stealthy direct replacement, a new stealthy platform, or new radars and systems. Ten years is a long time for UAV developments, and we cannot guarantee the US Navy will still be buying Triton, or MFAS, in 2027.

International Triton/MFAS Sales

Concerning international sales, in April 2018 the US Defense Security Cooperation Agency (DSCA) notified Congress of a $2.5 billion potential foreign military sale (FMS) of four MQ-4C Tritons to Germany – which are planned to fly in civil airspace, unlike Global Hawk, And in June 2018, the Australian government confirmed that it would acquire six MQ-4C Tritons (not seven as planned), with the first to enter service in 2023, followed by full operating capability in late 2025 when all six have been delivered.

Australia has always been fairly committed to buying Tritons, and of course Australia is also buying the P-8 Poseidon, which supports Triton integration. Australia faces an increasing near-peer (or better) naval threat from China. Much as Global Hawk has only sold to very few, very rich nations with a very high-end threat (always China… Japan and South Korea have ordered Global Hawk), Triton will likely remain very expensive with a very limited high-end market – which now includes Germany. Most of the world has bought General Atomics Predators and Reapers – much cheaper (especially to operate) and quite effective.

In fact, even India now seems to have dropped consideration of Triton – despite buying P-8I Poseidons – in favor of the General Atomics Reaper-based Guardian maritime UAV. With plans to buy at least 22 air vehicles, a Triton procurement would be massively expensive.

So, we include a small Undetermined production forecast next decade for MFAS and Triton. This could be more systems for Australia, a silver-bullet procurement for India, or most likely follow-on sales for Japan or South Korea. But this is highly speculative, and could go up or down.

Next-Generation HALE (High Altitude Long Endurance) UAV

Next-Generation HALE UAV

Whatever happens to Global Hawk and Triton, there will eventually be future development and production of unclassified HALE (High Altitude Long Endurance) UAVs, probably larger in size than General Atomics' Predator B Reaper and Predator C Avenger. The USAF's semi-stealthy MQ-X program was already in the planning stages, but has now been delayed or cancelled (and partly gone classified), while a follow-on to Global Hawk is some years farther out. This overview treats unclassified programs, which we expect will continue to run parallel to major classified programs such as the US Air Force's possible new, stealthy RQ-180.

The most obvious follow-on HALE would be an updated overland-optimized Global Hawk, which may still be reborn if the BAMS Triton is successful. However, as some of Global Hawk's disadvantages – a slow speed for long transits from base to mission area, and insufficient altitude capability to fly over some weather – have become apparent from recent Asia/Pacific operations, Global Hawk may no longer be an ideal HALE choice.

In any case, there will likely be a lull for several years before a major follow-on program. But Japan and South Korea's recent Global Hawk purchases reflect a continuing – probably growing – need for high-altitude long-endurance ISR, similar to the continuing need for the U-2. This need will not disappear, and a next-generation system will almost certainly be a UAV, to allow an

endurance greater than 12 hours, for use in Asia and globally where users cannot access local air bases.

The biggest question is probably whether a future unclassified HALE UAV will be stealthy, or partially stealthy, or simply be Global Hawk or an unstealthy follow-on to Global Hawk. Global Hawk has already been flying since 1998 (20+ years); another 20+ years is not at all unlikely. Teal Group has consistently assumed classified developments have continued in the US for ultra-stealthy ISR UAVs, and in 2013 the USAF revealed its RQ-180. Whether this means a long delay before a follow-on non-stealthy HALE is uncertain.

Next-Gen Sensor Suite Options

Whatever the platform looks like, Raytheon's Global Hawk EISS has already been less than totally successful. Beyond the immediate procurements by Japan and South Korea, a follow-on HALE will likely have a full sensor suite competition.

For future EO/IR competitions, expect UTC Aerospace/UTAS (was Goodrich) to bid a version of its SYERS sensor currently on the U-2 and other platforms, now to include the MS-177 for USAF Global Hawks. FLIR Systems, Inc. and L-3 WESCAM could no doubt develop systems, but so far they have not played in the high-altitude arena. Battling the Raytheon juggernaut will not be easy, but the rewards would be great (and already have been for UTAS – worth well over a hundred million dollars already…). There is also the possibility that old-school fighter tac recce suppliers such as BAE Systems could compete, probably teamed with other sensor and/or C4I firms. As a final (strong) possibility, a truly high-end system would tempt Lockheed Martin, the world leader in fighter targeting EO/IR systems, and Northrop Grumman, producer of both Litening targeting pods and the EO/IR situational awareness system for the F-35 Joint Strike Fighter.

For future synthetic aperture radar (SAR) competitions, "HISAR" has been even less successful than the EO/IR component of the ISS and EISS. Our Next-Gen HALE UAV SAR forecast addresses unclassified HALE UAV programs, which we expect will continue to run parallel to major classified programs such as the US Air Force's new, stealthy RQ-180 ISR UAV. The follow-on radar to HISAR could be for these future HALE UAVs, for new production Global Hawks, or even for upgrades to the EISS or HISAR in current Block 30 USAF Global Hawks. Our forecast is highly speculative, especially as unlike for the EO/IR component of the EISS, there are no current plans to replace or supplement the HISAR (which is why our Global Hawk Follow-On SAR forecast ends soon).

On the other hand, Raytheon has already developed an upgraded AESA ASARS-2B SAR for the U-2, which is entering production. There are currently no plans to buy the ASARS-2B for Global Hawk, but it will certainly provide a benchmark against which any future radar will have to compete (and just buying that in a few years, after it has been produced for the U-2, would make very good sense…). Our funding forecast for our Next-Generation HALE UAV SAR could well provide for radars for upgrading current Global Hawks rather than being exclusively spent for new platform development….

Thus, for both EO/IR and radars, as Global Hawk no longer looks a shoe-in for future HALE (but… it could be…), we have separated funding for future sensor development. Future funding is highly speculative, as schedules are unknown. Additional Global Hawk sales could occur soon, which could ramp up Next-Gen sensor funding very quickly.

Funding Forecast

RDT&E (FY19$ Millions)	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
All RDT&E										
ISS/EISS [Raytheon]	6.0	8.0	5.0	4.0	3.0	5.0	4.0	3.0	3.0	2.0
U-2 SYERS/Global Hawk Follow-On EO/IR [UTAS]#	44.0	34.0	42.0	40.0	48.0	42.0	28.0	32.0	30.0	36.0
HISAR [Raytheon]	2.0	4.0	3.0	2.0	3.0	1.0	2.0	1.0	1.0	1.0
Global Hawk Follow-On SAR (ASARS-2) [Raytheon]	4.0	—	—	—	—	—	—	—	—	—

Procurement (FY19$ Millions)	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
All Production and Upgrade & Support										
ISS/EISS [Raytheon]	38.0	**52.0**	**28.0**	**34.0**	**32.0**	**10.0**	**14.0**	**12.0**	**8.0**	**6.0**
U-2 SYERS/Global Hawk Follow-On EO/IR [UTAS]#	58.0	70.0	80.0	80.0	70.0	60.0	66.0	56.0	62.0	64.0
HISAR [Raytheon]	26.0	22.0	8.0	6.0	6.0	8.0	4.0	5.0	3.0	2.0

NOTE: For Global Hawk MP-RTIP and AGS funding, see MP-RTIP and AGS reports; for Triton EO/IR funding, see AN/AAS-44 & AAS-52 report
#=These funding lines include both Global Hawk and U-2 funding; these amounts duplicate those in SYERS (Senior Year EO Reconnaissance System) & MS-177 report (not in addition to)

RDT&E+Proc (FY19$ Millions)	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
All RDT&E and Production and Upgrade & Support										
Triton MFAS [Northrop]	150.0	180.0	184.0	342.0	448.0	366.0	310.0	384.0	380.0	396.0
Future Next-Gen HALE UAV EO/IR [Undetermined]	26.0	40.0	50.0	60.0	70.0	70.0	80.0	90.0	110.0	120.0
Future Next-Gen HALE UAV SAR [Undetermined]	48.0	64.0	82.0	78.0	86.0	102.0	112.0	124.0	128.0	130.0

Production Forecast

User (Platform)	Through 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
ISS & HISAR												
USAF (Block 0 RQ-4A)	4	—	—	—	—	—	—	—	—	—	—	4
USAF (Block 10 RQ-4A)	7	—	—	—	—	—	—	—	—	—	—	7
EISS & HISAR												
USAF (Block 20 RQ-4B)	9	—	—	—	—	—	—	—	—	—	—	9
USAF (Block 30 RQ-4B)	25	—	—	—	—	—	—	—	—	—	—	25
Japan (Block 30 RQ-4B)	1	1	1	—	—	—	—	—	—	—	—	3
South Korea (Block 30 RQ-4B)	4	—	—	—	—	—	—	—	—	—	—	4
Total	**50**	**1**	**1**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**52**
MFAS												
USN (Triton MQ-4C)	3#	2	2	4	2	2	4	5	5	5	5	39#
Australia (Triton MQ-4C)	—	—	—	—	1	1	2	2	2	—	—	8
Germany (Triton MQ-4C)	—	—	—	—	—	—	1	2	—	—	—	3
Undetermined (Triton MQ-4C)	—	—	—	—	—	—	1	1	1	1	1	5
Total	**3#**	**2**	**2**	**4**	**3**	**3**	**8**	**10**	**8**	**6**	**6**	**55#**

#Includes 2 Pre-LRIP systems

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