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COVER STORY

BY **JOHN KELLER**, EDITOR IN CHIEF

Embedded computing a crucial enabler of bistatic radar and sonar

Two surveillance technologies that have been in common use for more than half a century — radio detection and ranging (radar) and sound navigation and ranging (sonar) — may undergo substantial enhancements with the addition of remote transmitters.

These offboard transmitters could create a new generation of bistatic radar and sonar that could not only enhance the performance of these systems, but also preserve the stealthiness of weapons platforms like jet fighter aircraft and fast attack submarines. Read J.R. Wilson's special report on the new frontiers in passive radar and sonar on page 6.

Radar and sonar, in essence, represent relatively simple concepts: They both transmit energy that bounces off objects nearby and detect targets by receiving energy from the return signals. Radar bounces radio waves off targets, while sonar does the same with sound waves. An added benefit of radar and sonar is the ability to estimate the target's distance from the transmitter, based on the time it takes for the signal to bounce back. They detect potential enemies and give reasonably accurate estimates of how far away the enemies might be.

The problem with conventional radar and sonar systems, however, is their lack of stealth; any adversary in the vicinity knows someone's looking for him when he detects the radio emissions of radar systems or the sound emissions of sonar. It's a lot like turning on a flashlight in a darkened room; you can see things easily, but the world knows you're there.

Now take a moment to consider radar and sonar transmitters that are in different locations from their receivers. A detected enemy aircraft would be certain of the presence of a radar-transmitting aircraft, but a receive-only aircraft nearby would remain concealed. A receiving aircraft, based on return signals, could calculate a firing solution and launch air-to-air missiles before the enemy aircraft even knew he was there.

It could be the same scenario for attack submarines. A submerged adversary would know of a sonar-transmitting submarine, while a receiving submarine would remain concealed and could ready a sudden torpedo attack from an unanticipated direction.

Now let's consider a different approach. What if an attack aircraft could launch an unmanned aerial vehicle (UAV) with a radar transmitter on board, while the host aircraft kept its radar and electronics quiet? It could add a new dimension to the fight and create a fast-moving triangulating game of cat-and-mouse that could put adversaries in a big disadvantage at a crucial moment.

Apply the same idea to an attack submarine. That vessel could launch a torpedo-shaped unmanned underwater vehicle (UUV) with a sonar transmitter, detect and range enemy submarines in the area, and enable the quiet attack submarine to calculate a firing solution. This submarine-and-UUV scenario is exactly what the U.S. Defense Advanced Research Projects Agency (DARPA) is working on with the new Mobile Offboard Command and Control and Approach (MOCCA) program.

There's a reason bistatic radar and sonar haven't caught on in a big way: signal processing. Conventional systems involve two points (transmitter/receiver and target); the bistatic approach adds a third point: transmitter, target, and receiver. This third point complicates the sonar signal processing challenge, and adds difficulties of time lag, potential uncertainty of the relative positions of transmitter and receiver, and a host of factors that would require systems with supercomputer-like power.

Such challenges may be getting a solution with high-performance embedded computing (HPEC) technology. Embedded versions of the Intel Xeon processor could provide supercomputer power to deployed aircraft and submarines, and even new generations of UAVs and UUVs.

IN BRIEF

Raytheon to provide next-gen Navy shipboard SATCOM

Military communications experts at Raytheon Co. will provide the U.S. Navy with next-generation shipboard satellite communications (SATCOM) terminals under terms of a $102.9 million contract. Officials of the Space and Naval Warfare Systems Command (SPAWAR) in San Diego are asking the Raytheon Space and Airborne Systems segment in Marlborough, Mass., to provide Navy Multiband Terminals (NMTs), which ultimately are expected to be installed on about 300 Navy ships, submarines, and shore stations. This contract, announced on 29 Dec., has options that eventually increase its value to $466.6 million, Navy officials say. The NMT is a multiband-capable SATCOM terminal that provides protected and wideband communications. It supports extremely high frequency (EHF) communications; advanced EHF low-, medium-, and extended-data-rate communications; super high frequency (SHF) communications; military Ka-band transmit and receive communications; and receive-only Global Broadcast Service communications. ←

Navy looks to ATCA embedded computing architecture for Aegis upgrades

BY JOHN KELLER

HOUSTON — U.S. Navy shipboard weapons experts are capitalizing on the Advanced Telecommunications Computing Architecture (ATCA) to upgrade the Aegis weapon system for Navy cruisers and destroyers.

Navy officials are looking to Artesyn Embedded Technologies in Tempe, Ariz., to enhance, upgrade, and insert new technologies into Aegis, and are considering ATCA for future upgrades to the Ship Self Defense System, says Rob Persons, field applications engineer at Artesyn. Using ATCA for Aegis is part of an Artesyn project to adapt the Network Equipment-Building System (NEBS) design guidelines shipboard electronics in Navy surface warships.

The Aegis combat system uses computers and radar to track and guide weapons to destroy enemy targets. More than 100 Aegis-equipped ships have been deployed in five navies worldwide. Aegis was developed by the Missile and Surface Radar Division of RCA, now part of the Lockheed Martin Mission Systems and Training segment in Moorestown, N.J.

Artesyn's Aegis-related work is through the Navy and not specifically tied to Lockheed Martin, Persons says. Managing the Navy's Aegis systems are officials of Naval Sea Systems Command in Washington.

Navy officials refresh Aegis electronics about every four years. Previously designers had relied on the non-standard BladeCenter architecture for Aegis designs, but wanted to move toward the kind of open-systems architecture with ATCA they had used with VME, Persons explains.

U.S. Navy shipboard electronics experts are using Advanced Telecommunications Computing Architecture (ATCA) technology to upgrade the Aegis shipboard weapon system.

To adapt ATCA and NEBS building blocks to the Aegis Combat System, Artesyn engineers first stiffened an ATCA chassis sides and back, after having adapted the chassis top and bottom to the Aegis shock-isolated rack, Persons says. Experts also screwed boards into the chassis to resist the effects of shock and vibration. Navy officials say they would like to use this architecture aboard surface warships for eight years or more before considering new technology insertion approaches. The Artesyn ATCA architecture is useful for adapting third-party embedded computing products, Persons says. ←

FOR MORE INFORMATION visit **Artesyn** online at *www.artesyn.com*.

Army to combine C- and Ku-band SATCOM channels on one 16-meter antenna

BY JOHN KELLER

ABERDEEN PROVING GROUND, Md. — U.S. Army satellite communications (SATCOM) experts are surveying industry to find RF and microwave companies able to develop full-duplex SATCOM links that can operate on Ku and C bands from one SATCOM antenna measuring at least 16 meters in diameter.

Officials of the Army Contracting Command at Aberdeen Proving Ground, Md., issued a request for information (W56KGU13RA424) for the Advanced Technologies for Fixed and Transportable Satellite Earth Terminals-16-meter Dual-Band (Ku-Band and C-Band) Antenna project. The RFI, issued on behalf of the Army Research, Development and Engineering Command (RDECOM), Communications Electronics Research, Development and Engineering Center (CERDEC), is looking for SATCOM links at C and Ku bands, capable of both, but remotely selectable and only operating on one chosen band at a time.

C-band links operate on frequencies from 4 to 8 GHz for long-distance radio telecommunications and weather radar systems. C-band SATCOM signals perform better than Ku-band in bad weather due to attenuation from moisture. Ku-band links operate on frequencies from 12 to 18 GHz for SATCOM fixed and broadcast radio communication services, as well as for radar.

The Army is trying to improve tactical satellite communications by combining Ku and C SATCOM bands on one 16-meter antenna.

Army researchers are looking for a SATCOM antenna 16 meters or greater in diameter capable of receiving and transmitting simultaneously at the C and extended bands, officials say. It must be able to perform Ku-band full duplex operations in the C and Ku bands using the same aperture while simultaneously maintaining power and bandwidth requirements within the FCC and Intelsat standards.

Ultimately Army researchers want to sponsor a low-risk program that potentially leads to a test aperture at Aberdeen Proving Ground and 12 or more identical systems and system installations in various locations around the world.

For now, Army researchers are asking for industry white papers on the technical feasibility of combining C- and Ku-band capabilities into one aperture; the estimated time necessary to develop such a system; potential production rates; the feasibility of installing several systems simultaneously in different locations; and the performance of the system in various configurations.

MORE INFORMATION IS online at *https://www.fbo.gov/notices/85eb9e98f75ffaae7378bb7361ff02d8.*

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New frontiers
in passive radar and sonar

Passive sensor systems may be ready to come into their own, as high-performance embedded computing technology becomes powerful enough to handle the massive computing load that passive systems require in targeting stealthy aircraft and submarines.

The Lockheed Martin F-22 Raptor is a 5th Generation fighter incorporating stealth shaping and radar-absorbent materials, as well as a passive radar detector with more than 30 antennas blended into the wings and fuselage for all-round coverage.

BY **J.R. Wilson**

Radar and sonar technologies came into their own as pivotal capabilities in World War II, during the Battle of Britain, the Battle of the Atlantic, and many other battles that helped shape the latter half of the 20th Century. Research in the 1930s led to widespread deployment of active radar and sonar systems across three operational domains — air, land, and sea — during and after World War II.

For the past half century, efforts to defeat both have spawned generations of stealth technology and a renewed focus on passive radar and sonar, which actually predate active systems by three decades.

Radar, short for radio detection and ranging, bounces radio waves off objects to calculate their distances from the RF transmitter. Sonar, which stands for sound navigation and ranging, bounces sound waves off objects to calculate their distances from the sound transmitter. Most often sonar is for detecting and locating surface vessels, submarines, or other maritime objects for detection and tracking or to assist navigation and obstacle avoidance.

The biggest drawback to both is they are the equivalents of flashlights in the dark: While they help the user illuminate targets of interest, they also help others see the location of the user. That has led to development of less visible approaches that involve RF and sound

transmitters that appear to be causing random noise, rather than conducting a determined search.

"There are spread-spectrum transmissions for radar that is an active technique that, instead of a blatant pulse train, it appears you are putting out noise and it's not as obvious you're there," says Marc Couture, senior product manager, digital signaling at Curtiss-Wright Defense Solutions in Ashburn, Va.

Passive radar and sonar systems, however, do not generate their own signals at all. They capitalize on existing signals in the environment, and the passive radar and sonar receivers essentially just listen for those signals and use power signal processing to sort these signals into useful information.

"With passive techniques, you rely on the environment to light up objects," Couture says. "In 2016, there are a lot of things that light up everything around you in terms of radio emissions. With passive radar, radio waves bouncing off each other from a host of other sources can give you a picture without sending out your own pulse. That also is true with sonar — if you have a sensitive enough system, you can pick up objects without sending out a ping."

Sensitive sensors

"Both require extremely sensitive sensors, certainly more than just one single-point sensor, and a lot more processing," Couture explains. "If you think of radar, you put out a pulse train and expect it to come back, modified by whatever it bounces off. With passive, you're using reflections off clutter and buildings to pull out a target in the sky, so there is a lot more work to correlate all those different wavefronts."

One way to understand that is to look at the downfall of H.G. Wells's Invisible Man character, who could be seen — and tracked — when his invisible body caused what appeared to be a bubble in rain or fog.

In the real world, of course, stealth platforms are not invisible to the naked eye, but appear as something else — usually much smaller — on radar or sonar. There have been two primary ways to do that: special shaping, such as used on the

F-117 Nighthawk, the world's first stealth aircraft — or special materials that absorb rather than reflect radar signals, as used on the second stealth aircraft, the F-22 Raptor.

Both methods also have been used on surface and subsurface naval vessels, such as the Navy's new Zumwalt-class guided missile destroyers and Virginia-class attack submarines. More recently it's been used in designs for next-generation unmanned aerial vehicles (UAVs).

These platforms represent the U.S. military's generational lead in stealth over the rest of the world and proved vital to air superiority in the first and second Gulf wars. But a future conflict with a technologically near-peer adversary — such as China, Russia, or Iran — or nations they support could see that advantage melt way. Not because those nations are developing their own stealth platforms — which they have been working on for years — but because they are concentrating on far less expensive and easily deployed counter-measures.

"Faced with the prospect of aerial stealth proliferation, states in the 21st Century are looking for anti-stealth defense options. One such alternative, passive radar, appears a cost-effective counter to stealth," according to an October 2009 National Defense University (NDU) report, "Radar vs. Stealth: Passive Radar and the Future of U.S. Military Power," that is even more pertinent today.

Finding stealth aircraft

"Integrating a system of netted receivers, passive radar can detect, track, and target piloted and unpiloted stealth systems and provide cuing for anti-air weapons systems," the report states. "A passive radar system emits no radio energy and can be well camouflaged in urban and rural landscapes. The threat system produces no indications on friendly radar warning receivers and is difficult to locate and target. Faced with a passive radar threat, the United States may find itself unable to achieve air superiority at an acceptable cost."

Essentially, passive systems reverse the concept of stealth, from hiding ships and aircraft from radar and sonar to hiding radar and sonar from those platforms. Which explains why much of the public literature on passive radar and sonar is coming from

China, Iran, and Russia.

"Ongoing advances in passive radar will deny traditional means to defeat enemy air defenses, make air superiority difficult to achieve against a passive radar opponent, and require changes in thinking to maintain U.S. power projection capability," according to the NDU report.

In February 2015, an online affiliate of Russian newspaper *Rossiyskaya Gazeta* announced Russia's top five most effective electronic warfare (EW) systems. Number two on that list was the Moskva-1, a passive radar system that enables Russian troops to detect and identify airborne targets as far as 240 miles away while their own position remains hidden.

As global communications systems continue to advance and proliferate, the availability of opportunity illuminators increases, as well as not only land-based systems, but also satellites. One of the newest systems showing great potential for passive radar is long-term evolution (LTE), which has greatly improved cell phone signals.

"Experimental results showed that the LTE-based passive radar system has the capability to detect car, motor bike, and human body moving with various speeds, such as 10, 20, 30, and 40 kilometers per hour, and they are detected at different ranges from zero to 130 meters. Therefore, from the experimental results, there is no doubt that the LTE signal can be utilized as a signal source for PBR [Passive Bistatic Radar] system," according to researchers at Universiti Putra Malaysia.

Research in passive systems

"In spite of the positive results obtained, it should be pointed out that

The future USS Zumwalt (DDG 1000), the U.S. Navy's largest destroyer, incorporates stealth shaping and materials. The multimission ship will provide independent forward presence and deterrence, support special operations forces, and operate as an integral part of joint and combined expeditionary forces. (Navy photo.)

there is still a need for further studies and improvements," researchers say. "A future study could include implementing advanced signal processing algorithms for improving detection accuracy. Furthermore, more experiments could be conducted for investigating the system's capability for detecting and tracking of moving targets at a very low speed and low target profile."

At the University of Strathclyde in Scotland, researchers also looked at the Global Navigation Satellite System (GNSS) as a source of illumination for passive radar, including the possibility of exploiting GNSS as an opportunity illuminator to measure the micro-Doppler signature of helicopter rotor blades.

This approach represents "a system exploiting the energy transmitted from these non-cooperative transmitters... and has been successfully investigated in different configurations and using different sources of illumination," University of Strathclyde experts reported. "This kind of technology has several advantages thus opening to many applications for civilian and military purposes. Exploiting an existing source of RF energy, the system can be cheaper, stealthier, frequency allocation-free, and provide the capability to have information in portions of the spectrum unavailable in the past."

Active sonar can be a greater danger to the submarine using it than active radar is to an aircraft, which has significantly limited military use of it, as described by former U.S. Navy attack submarine sonar technician Steve Jacobs in response to a question on Quora.com, an online service providing expert answers to questions on any topic.

"In order to detect a contact with a ping, the sound has to travel at least two times the distance between the target and the submarine, plus have enough energy when it arrives to be detected by the submarine. If the sub (or any ship) is automatically pinging, the 'range gate' lets others know what distance the ship transmitting can detect contacts as well as what kind of sonar is being used," he wrote. "The only time we've pinged in a tactical situation is to take a single ping to verify a final range to a target we were going to engage with a torpedo."

The rising interest in and use of passive systems does not mean America's stealth platforms are obsolete nor the nation's multi-billion dollar investment in them was wasted. Stealth gave U.S. forces a distinct military advantage in Iraq, during Operation Desert Storm and Operation Iraqi Freedom, and Operation Enduring Freedom-Afghanistan and continue to aid in U.S. military operations against ISIS.

Big challenge to stealth

The ongoing development of passive systems by nations that supply equipment to Second and Third World nations hostile to the United States is likely to reduce their stealth effectiveness severely in the years to come.

This has led some of the U.S. military's top officers to question the wisdom of relying too heavily on stealth to counter the anti-access and area-denial (A2/AD) threat American aircraft are certain to face in future conflicts. Chief among those has been Chief of Naval Operations Adm. Jonathan Greenert, who says "if something moves fast through the air, disrupts molecules and puts out heat... it's going to be detectable."

That also was the conclusion of a January 2014 paper by the Center for a New American Security: "One recent analysis argued that there has been a revolution in

detecting aircraft with low RCS [radar cross-section], while there have not been commensurate enhancements in stealth."

Curtiss-Wright's Couture, however, sees passive systems not as the enemy of stealth but as a significant part of future stealth systems.

"With passive, it's part of being stealthy. But it's not just the shape of the aircraft and materials that cut down the radar cross-section; now you have sensors that don't light up the aircraft after you've done all that to try to hide it. So it will give us an advantage — although there are some adversaries that will catch up and find ways to hide themselves. So how do we find them?" he says.

"A lot of passive will be in more stand-off platforms that may assist special operations but not be part of it. You'll be able to map out the actual war theater in incredible detail without being detected. It's about prosecuting an enemy target and they don't know you're coming," Couture continues. "If a drone is using passive radar techniques, as long as it has enough power, you won't see it coming on a radar screen and you're zapped before you even know it. So the first nations to field that kind of capability will have an advantage."

Nazi Germany employed a passive bistatic radar system during World War II, using Britain's own Chain Home radars as non-cooperative illuminators to reveal the presence of aircraft flying over the southern part of the North Sea. Even so, bistatic radar systems were largely replaced by monostatic systems as early as the late 1930s. As the transmitter and receiver systems became smaller, it became possible to place them on aircraft and most ships. Bistatic systems regained some attention when scientists discovered useful properties in scattered radar energy.

Those experiments and others led to the 1955 deployment of the AN/FPS-23 fluttar bistatic radar system along the North American Distant Early Warning (DEW) Line to detect low-flying bombers. That system remained part of the DEW Line for about five years.

Passive radar saw its own initial resurgence in the 1980s as computing power and digital receiver technology began rapid increases in capability, allowing digital signal processing exploiting a variety of non-cooperative opportunity illuminators and, for the first time, cross-correlation techniques to detect targets and estimate their ranges. Many nations conducted classified development in this area, but the first public announcement came in 1998 with the launch of Lockheed-Martin's commercial Silent Sentry system, exploiting FM radio and analog television transmitters as opportunity illuminators.

Processing requirements

'We like to build high-performance embedded computers with all sorts of embedded processing technology. With passive radar and sonar, you need a lot more processing because you have a lot more data to collect and correlate. And when sensors are more sensitive, analog to digital converters have a higher bit rate, which means the actual high-resolution data is much larger," Couture says.

"If you have 16 channels instead of four, for example, you end up with a fire hose of data. With passive radar, the actual techniques are quite intensive. The processing technologies weren't there before, but now the densities are so high in computing you can think about using these in mobile platforms."

Relying on environmental RF and microwaves to light up the object, instead of a radar pulse and very specific radar stacks and algorithms honed in on that return pulse, the algorithms are far more intensive, correlating wavefronts from stationary and moving surface objects," he says. "In the past, that has been a major roadblock to using passive radar on smaller platforms, such as UAVs, that have a limited payload for volume and power.

The nation's newest and most advanced nuclear-powered attack submarine, the USS Virginia, has the BQQ-10 bow-mounted spherical active/passive sonar array and stealth shaping and material technologies for naval vessels. (Navy photo.)

"With this advanced processing power, you need to process all these new algorithms to track objects without giving away your location, which is especially valuable for stealth aircraft," Couture continues. "And that trend will continue as we have more cores and get more parallel, providing more density performance per watt, so you will see more algorithms coming off the shelf at DARPA and MIT that were not affordable and were too intensive in the past. It's not just one algorithm that fits all scenarios — you will use different ones over urban areas than deserts, for example."

Much work needs to be done in the digital signal processing community before this could be considered a mature technology. "It is really very early, so what is out there now is primitive compared to what will be out there in the future, maybe a decade from now," Couture says. "That will be riding the continuation of Moore's Law on processing, new algorithm development, dealing with stealth technologies. With conformal antennas you can absorb from all directions, which increases the data hose. A communications band that used to be 20 MHz to 3 Gig has now expanded out to 6 Gig and the classic EW bands have expanded to 27 Gig. Some new radars also operate at a higher frequency, so there are new wavelengths to prosecute; to use these passive techniques, you need more processing to deal with more channels and wider bandwidth."

In a 2015 paper, "Target Tracking and Receiver Placement in MIMO DVB-T Based PCL" from Iran's Sharif University of Technology, researchers looked at the electronic warfare applications of using multiple antennas for transmission and reception of a passive radar system in a multiple input/multiple output (MIMO) configuration.

"The idea of using multiple of such illuminators to get the advantages of MIMO technology, besides the advantages of passive illumination, is new and attractive," they wrote. "An excellent candidate of such configuration is a DVB-T [Digital Video Broadcasting-Terrestrial]

SFN (single frequency network). Various obstacles and considerations appear when working with a MIMO DVB-T based passive radar system. Using the commercial transmitting stations already working in the environment as the non-cooperative transmitter of the radar system makes the radar covert."

Electronic warfare

"This passive radar — or namely PCL (passive coherent location) — is resilient to electronic countermeasures which use the signals emitted by the radar. In such passive systems, two sets of antennas are used: one for receiving the direct signal from its main source (reference antenna) and another one for collecting reflections arriving from the targets (reflection antenna). Here, detection is done through computation of CAF (Cross Ambiguity Function)... which shows how much correlation exists between reference and reflected signals. A CAF's peak in the range Doppler board is representative of a target candidate."

Passive radar systems in the future may help with military surveillance and reconnaissance effectively by hiding the RF transmitters in these systems.

In July 2015, researchers at Pakistan's National University of Sciences and Technology reported on the effects on the range measurement accuracy of a Wi-Fi-based

passive radar when multiple copies of signal, from the same target, are received due to propagation through a rich-scattering environment.

"These multipath returns from stationary scatters induced range measurement inaccuracies in passive radars including offset of the target from its true range, smearing of the target in range dimension, or appearance of ghost targets," they wrote. "Relationship between range measurement inaccuracies due to target multipaths and range resolution of transmission waveform has been studied. A two-step solution, that is, signal separation followed by equalisation, is also proposed to mitigate the effects of multipaths in Wi-Fi-based passive radars.

"Long-range surveillance applications of passive radars, using various analog and digital waveforms, have reached a point of maturity and practical systems have started to appear in market for various defense and civil applications, like Silent Sentry by Lockheed Martin, Celldar by Roke Manor Research Limited, and Homeland Alerter 100 by Thales Group. Owing to the many advantages offered by the passive radars, there [also] is a growing interest to utilize them in urban and indoor sensing environments for the detection of human or vehicular targets."

Dealing with weak signals

Three researchers at Villanova University and one from the Air Force Research Laboratory published a paper on "Target Localization in a Multi-Static Passive Radar System Through Convex Optimization" in *Signal Processing*, a publication of the European Association for Signal Processing, in February 2014. They concluded the use of pre-existing commercial broadcast signals rather than dedicated transmission and receipt stations may be as much a weakness as a strength.

"Compared to conventional active radar systems, which typically operate in a monostatic mode and emit stronger signals with a wide signal bandwidth, MPR [multi-packet reception] systems use broadcast signals which in general are very weak and have an extremely narrow bandwidth. These features make it difficult to exploit an MPR system for accurate target position estimation. In addition, MPR receivers may often be implemented on aerial or ground moving vehicles. In this case, the radar platform may only have inaccurate knowledge about its own instantaneous position. This uncertainty is caused by the accuracy limitation of the positioning system as well as multipath propagations," they wrote.

Passive sonar has been in use for decades, and is one an effective means of detecting an adversary's submerged submarines while remaining hidden to enemy sensors.

"Target localization is an important task that has received extensive attention in various applications, such as wireless communications, sensor networks, urban canyon, and through-the-wall radar systems. Specifically, multi-lateration techniques utilize the range information observed at multiple positions, which are distributed over a region, to uniquely localize a target. Depending on the applications, range information can be obtained using time-of-arrival, time-delay-of-arrival, and received signal strength indicator. On the other hand, the observation positions may be achieved using fixed receivers or synthesized using a single moving platform. In the latter case, the receiver positions are subject to inaccuracy."

The ultimate future of passive radar and sonar is still to be determined — as is which nations will achieve the highest levels and broadest applications first and most effectively. Even more than acceptance by military leaders, that will depend on the continued maintenance of American technological leadership through aggressive research and development.

"You can have a fleet of assets that can handle multiple modes and, on top of that, cross-cuing. It's about commanding the entire EM spectrum, which includes not just RF but light and hyperspectral. It's a software-defined platform," Couture says. "The labs are very important because there is always a need for advanced algorithms because we don't have every mode solved or every adversary in check. I can't say I've seen a big pickup in demand [from the military], but I do anticipate it."

Common technologies for manned and unmanned aircraft

Military jet fighters, commercial passenger jetliners, military surveillance aircraft, as well as a growing number of unmanned fixed-wing aircraft and helicopters benefit from technologies designed for dual use.

BY **Courtney E. Howard**

The A400M military airlifter from Airbus Defence and Space takes advantage of various commercial technologies, including a glass cockpit. (Image courtesy Airbus and JV Reymondon.)

Manned and unmanned military and commercial aircraft share more common technology than ever before. From fuselages to engines and cockpit avionics to connectors, today's commercial and military jets, helicopters, and unmanned aircraft systems (UAS) leverage innovations from a wide variety of markets, including consumer electronics, automotive, industrial, medical, and more.

"Instead of technology migrating from military avionics to the commercial sector, there is significantly more transfer from the consumer electronics world into avionics in general," says Paul Hart, chief technology officer and technical fellow at Curtiss-Wright Avionics & Electronics in Christchurch, England. "For example, traditional MIL-STD-1553 and ARINC 429 databuses are giving way to Ethernet-based networks on aircraft, along with Wi-Fi connectivity. Also CANbus, used in the automotive industry for decades now, has an ARINC standard and is featuring in many new aircraft designs.

"There are also crossover technologies where other industries have invested in technology development that can benefit aerospace," Hart adds. "For example, we are using a sensor technology originally developed for the medical industry to detect ice accretion on an aircraft wing to much higher accuracies than existing technology. We have also evolved versions of our flight test instrumentation for space applications on launch vehicles, spaceplanes, re-entry vehicles, and space stations."

Benefits abound

Collaboration across aerospace and other industries is increasing, and virtually all involved are benefitting.

Military aircraft are leveraging commercial avionics systems and components, and even fuselages. As a result, military programs are able to save development time and money; benefit from commercial economies of scale for reduced costs, increased product availability, and potentially, reduced threat of parts obsolescence; and boost compliance with safety standards and requirements for flying in public airspace.

Simultaneously, commercial aircraft — from airliners to civil and

Poseidon partnership

The Boeing-led P-8 Poseidon industry team includes Raytheon in Waltham, Mass.; Northrop Grumman Corp. in Falls Church, Va.; Spirit AeroSystems in Wichita, Kan.; GE Aviation Systems in Cheltenham, England; Marshall Aerospace and Defence Group in Cambridge, England; CFMI in Cincinnati; BAE Systems in Nashua, N.H.; and Marotta in Montville, N.J.

CFM International, a 50/50 joint company of Snecma Moteurs and General Electric Company, provides the CFM56-7 commercial engines that have logged more than 30 million flight hours.

Northrop Grumman's Electronic Systems sector provides the directional infrared countermeasures system and the electronic support measures system. Northrop Grumman's Aerospace Systems sector develops data links for the P-8A; the company's Integrated Systems sector supports the mission planning effort.

Raytheon provides the AN/APY-10 radar, which delivers all weather, day/night multimission maritime, littoral, and overland surveillance capabilities, as well as the MK 54 lightweight torpedo.

GE Aviation supplies the Flight Management system, an integrated open architecture that is CNS/ATM compatible with a growth path for upgrades, and a Stores Management system for the electronic control of integrated weapons management.

Spirit AeroSystems builds the 737 aircraft's fuselage and air-

The Boeing P-8A military jet is assembled alongside 737 commercial passenger jets.

frame tail sections and struts in Wichita, Kan.

BAE Systems provides the mission computing and display system (MCDS), flight deck panels, and data diode. "Our mission computer suite is the digital backbone for the P-8A aircraft. It provides an interface to all sensors, communication links, countermeasures, and aircraft subsystems on board," says Gary Rubasch, program director at BAE Systems in Greenlawn, N.Y., where the MCDS is assembled and tested. "Airborne sensors in surveillance aircraft require flexible open-architecture designs that are ruggedized for demanding military needs."

Engineers at the BAE Systems Electronic Systems segment in Nashua, N.H., selected LCR Embedded Systems Inc., a manufacturer of backplanes and ruggedized integrated chassis in Norristown, Pa., to supply the chassis that houses mission computer systems on-board the P-8A. LCR is expected to deliver 13 different chassis assemblies for the P-8 program past 2020 as the U.S. completes its P-3 to P-8A fleet transition, officials say.

consumer UAS — are harnessing proven rugged military electronics designed for several decades of usable life and for harsh environments.

Devised for dual use

"Many avionics devices and systems are designed for dual use — commercial and military applications — which not only enables shared capabilities and standards, but also helps to drive down development and qualification costs," Mike Madsen, vice president of aerospace integrated supply chain at Honeywell Aerospace in Phoenix, told *Military & Aerospace Electronics* in 2011. (Read "NextGen is happening now in avionics systems" from the August 2011 issue online at http://bit.ly/1RJ8EQg.)

The trend of engineering dual-use technologies not only endures, but continues to expand. In fact, virtually every leading prime contractor to the U.S. Department of Defense (DOD) designs and develops technologies applicable across myriad markets, including commercial and military aerospace.

Within Honeywell Aerospace's marketing and product management team is "an Aerospace level, cross-functional organization ensuring technology roadmaps are coordinated to support current future requirements in commercial and military business segments," says Tom Hart, vice president defense and space aftermarket at Honeywell Aerospace in Phoenix. Honeywell's military customer base — original equipment manufacturers (OEMs) and aftermarket — is showing "high interest in commercial off-the-shelf (COTS) or military off-the-shelf (MOTS) when possible to reduce non-recurring and recurring" engineering costs.

U.S. Coast Guard air crews unhook an MQ-8C Fire Scout UAS, based on the Bell 407 commercial helicopter, on the Coast Guard Cutter Bertholf. (U.S. Coast Guard photo by Petty Officer 2nd Class Luke Clayton.)

"Honeywell Aerospace is very interested in dual use where possible. Significant investments are going into product and technology areas for commercial and military use," Hart says. "For example, Honeywell has developed a family of image processing modules (IPM) used in commercial display systems and military display systems where there is a need for increased processing power and throughput, like in a Synthetic Vision System (SVS) and Enhanced Vision System (EVS)." The same family of IPMs is used for high-end military display generator applications, such as the latest-generation F-15 and F-16.

"The Lockheed Martin F-16 is a great example of a legacy fighter with models delivered 30-plus years ago, but from an avionics

Best of both worlds

The TopMax commercial head-up display is based on military HUDs.

"Cockpit solutions for commercial airliners and military aircraft are obviously very different, partly due to the physical space available, but there's a lot of overlap between the underlying technologies," says Laurent Lenoir, vice president of the mission and function center of competence at Thales Avionics in Toulouse, France. "Thales designs modular systems with an open architecture that can achieve civil certification as well as meet the specific requirements of tactical missions."

Lenoir cites the Airbus A400M Atlas, a four-engine turboprop military transport aircraft, as a prime example. "This plane is designed with an Integrated Modular Avionics (IMA) suite that meets civil standards, and we added a host of specific military features and functions, such as data encryption, to ensure a high level of security," he says, noting that Thales does the same for helicopters and UAS.

The A400M features a full glass cockpit, common in Airbus commercial aircraft, and aircraft systems based on those in the A380 double-deck, wide-body, four-engine commercial jet airliner, but modified for military missions. In fact, it is designed with dual technologies that meet civil airspace certification standards and military specification (mil-spec) requirements.

"This platform uses the latest technology from Airbus civil aircraft, including a glass cockpit and side-stick controllers for the fly-by-wire flight control system. Unlike commercial airlines, it uses head-up displays as primary flight instruments, enhanced by large multifunction displays and, on some models, by the Enhanced Vision System, which uses a camera to assist pilots," officials say.

Thales supplies systems used in the A400M cockpit (head-down and head-up displays, control display system, and flight management system) and throughout the aircraft's avionics (IMA suite, multimode navigation, electrical systems, and utilities such as door management systems).

The A400M is the first military aircraft to be fitted with the IMA suite, developed for the A380 and tailored to the specific requirements of the A400M, according to Thales officials. "The IMA has been adapted to meet military criteria for resistance to higher vibration levels, higher electromagnetic compatibility, and a critical lightning protection system. Through its IMA platform, Thales has halved the number of parts required.

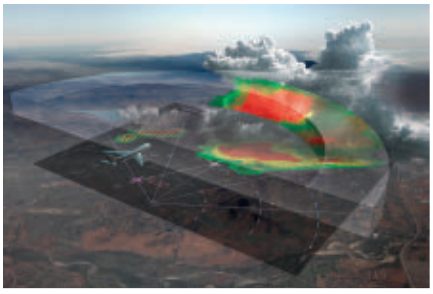
"Integration of the Thales-designed Control Display System (CDS) on the A400M marks the first time that interactive and reconfigurable screens are used on a military transport aircraft," officials describe. The CDS features eight interactive LCD screens that are sunlight-readable, compatible with night vision goggles, and derived from the system developed for the A380 commercial airliner. Additionally, they say, the A400M is the first Airbus aircraft to be pre-fitted with the HUD.

Thales developed the A400M's Flight Management System, the human-machine interface between the pilot and aircraft systems, to offer "most of the functionality associated with a top-level commercial airliner, combined with the specific functions required for tactical missions," Thales officials explain. As a result, they add, the A400M can fly missions with fewer crew members than are needed on other types of military airlifters, and it is compliant with civil air traffic standards for efficient insertion into civil air traffic and at commercial airports.

standpoint is up to today's standard in technology and capabilities," Hart explains. There are many opportunities to work on modern platforms, he says, but also significant opportunities to apply modern systems to upgrade legacy aircraft.

Convergence

The objectives of commercial and military organizations — from airlines to defense departments — are



Honeywell's IntuVue 3D weather radar is used on commercial and military aircraft.

converging. Both segments focus on acquiring advanced hardware and software having low cost and weight, high availability, an upgrade path for the future, and compliance with industry standards and regulations.

"In general, military aviation authorities around the world are adopting commercial — i.e., Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) — [standards] in place of milspecs, which have become quite dated and irrelevant to the technologies used in new avionics designs," says Curtiss-Wright's Hart. For example, "MIL-HDBK-217F, used widely for predicting reliability, has no consideration for software and field-programmable gate array (FPGA) implementations. There are much better techniques in the commercial world to predict reliability of a processor-based hardware system.

"Certification standards are predominantly based on commercial practices," Hart adds. "For example, the process of designing and manufacturing avionics under Part 21G, certifying against FAA/EASA technical standards, and designing installations under the STC or EASA Part 21J process are very clearly defined and have been implemented by the latest generation of aviation professionals. Also many environmental test labs are better equipped and more familiar with RTCA requirements, such as DO-160G 'shake & bake' than traditional MIL-STD-461 (electromagnetic compatibility or EMC) and MIL-STD-810 (environmental qualification) requirements."

"While there are still many unique military requirements, we definitely see commercial standards, such as RTCA DO-178, coming into the military systems, especially where civilian certification is required (e.g., communication, navigation, and surveillance/air traffic management systems)," Honeywell's Hart explains.

Head-mounted display for civil pilots

Thales Group officials and engineers in Toulouse, France, focused on designing and developing dual-use technologies, debuted what they are calling the first civilian head-worn display, the TopMax, at the 2015 National Business Aviation Association (NBAA) convention and exhibition, in Las Vegas last November.

The head-worn display for civilian pilots leverages Thales' experience in civil/military applications and military helmet-mounted sight display (HMSD) and head-up display (HUD) development, officials say. "The result is TopMax is a lightweight head-worn display that bridges the technological gap between a military HMSD and a civilian HUD."

First demonstrated at Paris Air Show 2015, TopMax is designed to combine the low-visibility take off/landing functions, Enhanced Flight Vision, and Synthetic Vision capabilities of a fixed HUD, with the 360-degree field of view, total eye-out functionality, and head-tracking system for target designation and cueing functions of an HMSD.

"This evolution allows a civilian pilot to look at objects like 3D traffic to better understand their position and, in some cases, like waypoints, select them for inclusion in the FMS as direct destinations, in the same way a military pilot can select targets visually for inclusion in targeting operations," officials say. "Both [commercial and military pilots] face challenges such as approach and landing at smaller airports with low visibility conditions and require a high level of situational awareness in a highly flexible operational context."

"Being inspired by our military applications to produce innovative products for the civil market is part of our DNA, but in TopMax we believe to have developed true game changer.," says Gil Michielin, Thales executive vice president of avionics.

Sharing airspace

Airline passenger traffic is up globally, and growing at an average rate of five percent annually, which is increasing competition for access to airspace among operators of virtually all aircraft, whether commercial airliners, business jets, helicopters, unmanned aircraft, or military aircraft.

"As commercial air traffic expands and the skies become busier, military aviation is having to adapt," says Laurent Lenoir, vice president of the mission and function center of competence at Thales Avionics in Toulouse, France. "With fewer routes reserved exclusively for military air traffic, military aircraft increasingly need to meet civil standards in order to fly in commercial airspace."

The military market benefits from great technology advances primarily driven by commercial airline customers in pursuit of lower cost, lower weight, and high performance and reliability, Honeywell's Hart explains. The RDR-4000 IntuVue in Honeywell's weather radar product line, for example, is fielded in commercial and business aviation aircraft and shares the same hardware and 95 percent of the software with the RDR-4000M fielded on military aircraft, including C-17 and multiple C-130 variants.

"We are seeing similar trends in traffic collision avoidance systems (TCAS)," Hart says. "The same hardware is used for commercial and military applications, and a reuse of core software adapted to support unique military functions. We are also using our family of TCAS processors as a core element in sense-and-avoid systems for larger UAS.

"Another area where core technology is used in commercial and military is navigation and, in particular, inertial navigation," Hart adds. "The same core Ring Laser Gyro is used in Honeywell's commercial Laseref inertial navigation family and H-764G family of Embedded GPS and Inertial systems for the military. The same trend is seen and welcomed in many other technology areas."

Hart also sees greater interest in "open architecture systems and standards. The DOD Future Airborne Capability Environment (FACE) initiative is an example of this trend," he says.

FACE features

The FACE approach is "a government-industry software standard and business strategy for acquisition of affordable software systems that promotes innovation and rapid integration of portable capabilities across global defense programs," as defined by The Open Group, a global consortium "that enables the achievement of business objectives through IT standards."

Many suppliers to defense organizations worldwide take part in The Open Group's FACE Consortium, with the goal of delivering modern, capable, and robust avionics to military

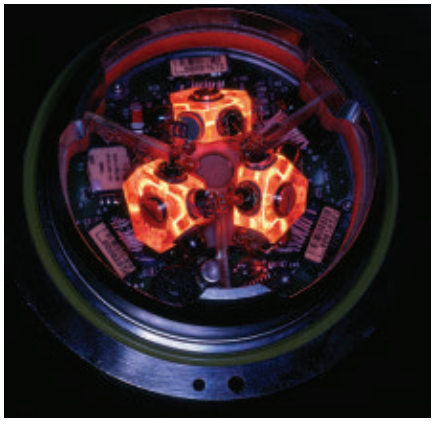
aircraft and operators in less time and at lower cost than historically possible through traditional methods and proprietary solutions.

Rockwell Collins in Cedar Rapids, Iowa, is a sponsor and founding member of the FACE Consortium. The company is supporting government development of a standard set of interfaces for Required Navigation Performance Area Navigation (RNP RNAV) capability aligned to the FACE Technical Standard.

Under a U.S. Naval Air Systems Command (NAVAIR) contract announced in January, Rockwell Collins will demonstrate its FACE-aligned Flight Management System application on military representative mission computer hardware in multiple configurations. The company's RNP-RNAV application leverages commercial technologies that are currently operational on commercial and tactical aircraft.

"Our open-architecture Flight Management System software is written for fast and affordable integration across a wide variety of avionics systems," says Troy Brunk, vice president and general manager of airborne solutions for Rockwell Collins. "Its RNP RNAV capability provides full civil airspace interoperability while ensuring timely and efficient mission planning and execution."

Rockwell Collins engineers upgraded U.S. Army CH-47F Chinook multi-mission, heavy-lift transport helicopters — already equipped with the Rockwell Collins Common Avionics Architecture System (CAAS) — with RNP-RNAV technology in 2015. The enhanced capability enables Chinook pilots to operate in and around civil airspace with safety benefits previously afforded only to commercial aircraft, officials say.



The same Honeywell Ring Laser Gyro is used in commrecial and military aircraft systems.

"RNP-RNAV provides tactical helicopters with full civil airspace interoperability under current flight rules. It eliminates the need to obtain waivers or be limited to non-preferred routing, while ensuring timely and efficient mission planning and execution," Brunk explains. "Our seamless integration of RNP-RNAV capabilities with the Chinook's combat-proven tactical flight and performance management system exemplifies how Rockwell Collins is a leader in bringing open system architecture solutions to our military customers through software-only upgrades."

P-8A production

Officials and engineers at Boeing Defense, Space & Security in Berkeley, Mo., adapted the Boeing Next-Generation 737-800 single-aisle passenger jet for military use, debuting the U.S. Navy P-8A (replacing the P-3C) and P-8I variant for India. The Boeing P-8 Poseidon is a long-range anti-submarine, anti-surface warfare, and intelligence, surveillance, and reconnaissance (ISR) military aircraft intended to combine the performance and reliability of a passenger jet (4,000 Boeing 737 commercial jets flying, with a 99.8 percent dispatch rate) with an advanced mission system designed for maximum interoperability.

The P-8 is reportedly the first military aircraft to be assembled on a commercial aircraft production line. Manufacturing the P-8 at Boeing's 737 assembly facility in Renton, Wash., "leverages the best of Boeing Commercial and Boeing Defense for development and production," officials say.

The P-8 can fly at altitudes as high as 41,000 feet at speeds to 490 knots, self-deploy as far as 4,500 miles from base without refueling, and fly in virtually all flight regimes, including harsh maritime and extended operations in icing environments, for 25 years or 25,000 hours over its usable life. It is powered by dual CFM-56B commercial engines, extends sensor reach to control unmanned aerial vehicles (level 2 control-receive), and enjoys commonality with 737 aircraft to streamline training and maintenance, and ensure parts availability.

The U.S. Navy P-8A shares the same airframe as the Boeing 737 family of commercial jets.

The Boeing P-8 Poseidon, growing in popularity and adoption, and is indicative of how many future military aircraft platforms are likely to

be approached: integrating advanced commercial and military technologies, as well as engineering and production workflows, toward a singular goal.

Unmanned helicopter

The U.S. Navy's next-generation unmanned helicopter, the MQ-8C Fire Scout, uses a commercial airframe based on a mature helicopter with more than 1,400 airframes produced and over 4 million flight hours, the Bell 407 four-blade, single-engine, civil utility helicopter from Bell Helicopter in Fort Worth, Texas.

Use of a proven commercial airframe translates to readily available spare parts and increased ease of maintenance, officials explain.

The airframe combines with a mature unmanned systems architecture from Northrop Grumman Corp. in Falls Church, Va., to provide ISR, target-acquisition, laser-designation, and battle-management capabilities to tactical users without relying on manned aircraft or space-based assets. "The MQ-8C Fire Scout combines the better of two proven air systems: the reconnaissance, surveillance, and target acquisition architecture of a UAS, and the extended range, payload, and cargo hauling capabilities of the commercially mature Bell 407 helicopter," officials say.

Engineering and production

Technology transfer between market segments and industries extends to engineering design, development, testing, and production workflows.

"The ongoing drive to reduce cost and weight have elevated the importance of 'value engineering' to secure better deals and long-term supply agreements on electronics components and sub-assemblies. Also, there is a trend to use additive manufacturing for less critical, load-bearing parts that were previously fabricated using CNC machining or casting," says Paul Hart, chief technology officer and technical fellow at Curtiss-Wright Avionics & Electronics in Christchurch, England.

Curtiss-Wright Defense Solutions product engineers harnessed additive manufacturing, also known as

Curtiss-Wright Defense Solutions debuted a 3D-printed AFT chassis well suited to rotorcraft and UAS.

3D printing, in the company's first functioning air-flow-through (AFT) chassis based on COTS 3U VPX modules. Curtiss-Wright Technical Fellow Ivan Straznicky demonstrated the 3D-printed plastic chassis integrated with the company's VPX3-1258 single board computer (SBC) and VPX3-716 graphics modules, during January's VITA's Embedded Tech Trends (ETT) embedded computing event in Houston.

The functional 3U AFT chassis demonstrator, supports the new VITA 48.8 Air Flow Through (AFT) cooling standard designed to benefit size, weight, power, and cost (SWAP-C)-constrained platforms, such as rotorcraft and UAS. Curtiss-Wright provides flight recorders with encrypted data storage, air data computers, ruggedized single-board computers, graphics cards, switches, digital signal processor cards, and flight test instrumentation are designed for and used on military and civil aircraft.

"Certainly the lines between engineers working on military and commercial lines has been blurred with probably the only distinction being when a non-national may not be allowed access or be employed on a military program in that nation," Hart says. For example, he adds, dual-use International Traffic in Arms Regulation (ITAR) components are avoided on many European programs and seen as a big risk to the onward export market.

In the end, Hart recommends "engineers and their bosses always be aware that the electronics are not designed for the avionics industry. The art of their trade is designing open-systems architecture that can use electronics developed for the industrial and computing markets for rugged applications, yet define upgrade paths to manage obsolescence and introduce technical refreshes at the lowest cost every five to eight years." Further, he advises, "be prepared to pay top-dollar for an avionics certification expert; they are worth their weight in gold and will save considerable time and money in the long run."

Adds Honeywell's Hart, "We see the future continuing down the current path it is on. With overlapping technology and military platforms adopting more and more commercial standards and systems and technology crossover, it would be great for engineers and engineering managers to get exposure to both areas and use the best standards and processes across the commercial and military market." ←

Raytheon to develop enabling technologies for next-generation missiles

BY **John Keller**

EGLIN AIR FORCE BASE, Fla.—Missile experts at the Raytheon Co. are researching how to increase capabilities for next-generation air-launched tactical missiles under terms of a potential $14 million contract.

Officials of the munitions directorate of the U.S. Air Force Research Laboratory at Eglin Air Force Base, Fla., are asking researchers at the Raytheon Missile Systems segment in Tucson, Ariz., to increase the number of missiles carried on a single sortie, the effectiveness of each missile, and platform survivability against all threats in an anti-access, area denial (A2AD) environment.

Specifically, the Air Force as asking Raytheon to conduct additional research and development on the Small Advanced Capability Missile (SACM) and Miniature Self-Defense Munition (MSDM) concepts.

The SACM will support affordable, highly lethal, small size and weight ordnance with advanced air frame design and synergistic control capabilities for air dominance enabling high air-to-air load-out. The SACM project seeks to provide flexible hyper-agile airframes, high impulse propulsion, affordable wide-field-of-view seeker, anti-jam guidance integrated fuze, and aimable kinetic and non-kinetic effects.

The MSDM, meanwhile, will support miniaturized weapon capabilities for air superiority by enabling close-in platform self-defense and penetration into contested A2AD environments with little to no impact to payload capacity. The MSDM seeks to develop an affordable guidance system for a future air-to-air munition designed for aircraft self-defense. The project will develop a conceptual design for the optics and algorithms of an affordable seeker front end for an air-to-air weapon for aircraft self-defense.

Raytheon is helping develop enabling technologies for the next generation of air-to-air tactical missiles.

The program involves aerodynamics, propulsion, warhead, and seeker front end. Cost is a primary driver. Raytheon experts will define system and subsystem requirements, explore design trades between subsystems and critical components, identify design risks, as well as model the launch aircraft, miniature self-defense munition, and two threats.

Raytheon will do the work in Tucson, Ariz., and should be finished by January 2021.

FOR MORE INFORMATION visit **Raytheon Missile Systems** online at *www.raytheon.com*, or the **Air Force Research Lab Munitions Directorate** at *www.eglin.af.mil/units/afrlmunitionsdirectorate*.

Military radar market to hit $15.7 billion by 2025

Global demand for military radar systems should increase by nearly 20 percent over the next 10 years, driven by growing use of radar systems and demand for early detection and situational awareness, predict Research and Markets analysts in Dublin. The global military radar market should increase from $13.1 billion in 2015 to $15.7 billion by 2025, analysts report in "The Global Military Radar Market 2015-2025." Airborne, ground-based, and naval radars will be the top three largest shares of the global military radar market over the next decade, as North America dominates the military radar market with a 38.5 percent market share.

Navy orders advanced shipboard radar systems

U.S. Navy leaders are ordering 12 advanced defensive shipboard radar systems from Northrop Grumman Electronic Systems in Baltimore under an $83.9 million contract. Officials of the Naval Sea Systems Command in Washington are asking Northrop Grumman to provide 12 AN/SPQ-9B radar systems to enable Navy surface warships to detect and track fast low-flying, anti-ship missiles with low radar cross sections in heavy radar clutter. The high-resolution, X-band AN/SPQ-9B radar will be integrated with the ships' fire-control systems.

Textron to provide Shadow unmanned aircraft and tactical data link retrofits

Textron Systems Corp. will provide new RQ-7B Shadow tactical unmanned aerial vehicles (UAVs) and ground-control systems under terms of a $97.1 million contract modification. Officials of the Army Contracting Command at Redstone Arsenal, Ala., awarded the contract modification to the Textron Systems Unmanned Systems segment (formerly AAI Corp.) in Hunt Valley, Md., for fiscal 2014 Shadow drone full-rate production VII in support of the Army and U.S. Marine Corps. This contract modification increases the value of the original contract, awarded last April, to $176.6 million. The contract modification calls for Shadow tactical unmanned aircraft system, tactical data link retrofit for full-rate production VII. The Army's fiscal year 2014 budget request called for buying 25 Shadow unmanned aircraft systems (UAS). The catapult-launched Shadow 200 tactical UAS provides Army and Marine Corps brigade commanders with reconnaissance, surveillance, targeting, and assessment. The aircraft can see targets from as far away as 78 miles from the brigade tactical operations center, and recognize tactical vehicles from altitudes as high as 8,000 feet above the ground at more than two miles slant range, day or night.

Air Force asks industry for new kinds of airborne sensors to find hidden targets

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio — U.S. Air Force intelligence, surveillance, and reconnaissance (ISR) experts are asking industry for new ways to design electro-optical and radar airborne sensors to detect and pinpoint mobile and hidden targets.

Special Forces and ISR officials of the Air Force Life Cycle Management Center (AFLCMC) at Wright-Patterson Air Force Base, Ohio, have issued a sources-sought notice (FA8620-16-R-4006) for the Airborne Sensors for Intelligence, Surveillance, and Reconnaissance project.

The project focuses on airborne sensor applications like signals intelligence (SIGINT) and geospatial intelligence (GEOINT) using electro-optical (EO), infrared (IR), multispectral imaging, and hyperspectral imaging sensor technologies, as well as ground-surveillance radar, full-motion video, light detection and ranging (LIDAR), and on-board data fusion.

Air Force officials may use the information from this industry survey to choose a preferred materiel solution for advanced airborne sensors. Experts say the project could help redefine medium- and high-altitude ISR sensors and shape Air Force efforts in the decade from 2020 to 2030.

Of particular interest are on-board sensor processing for several different kinds of aircraft; multi-intelligence sensor operations; and

Air Force researchers are trying to find new technologies for detecting and pinpointing hidden targets from unmanned aircraft.

sensor technologies to increase range and resolution as well as aid in rapid targeting.

For the purpose of size, weight, and power consumption (SWaP), proposals should assume the target aircraft for such technologies are the MQ-9 Reaper medium-range unmanned aerial vehicle (UAV), a business jet, and RQ-4 Global-Hawk long-range UAV.

Suggested technologies should be ready for prototype demonstration in a realistic environment by 2020, for initial operational capability by 2026, and for full operational capability by 2030.

Air Force officials are interested in non-proprietary open-systems architectures with on-board data processing for several different airborne sensors.

Companies interested should e-mail white papers to the Air Force's Ed Huling no later than 8 March 2016 at edward.huling@us.af.mil.

E-mail questions or concerns to Huling, or to the Air Force's Andrew Soine at andrew.soine@us.af.mil.

Navy wants sensors that penetrate through fog, haze, rain, and snow

BY **John Keller**

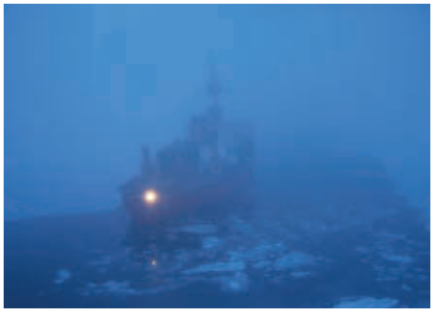
ARLINGTON, Va. — U.S. Navy shipboard electronics experts are reaching out to industry to find new sensor technologies to enable surface warship and submarine crews to capture images through difficult obscurants like fog, haze, rain, and snow.

Officials of the Office of Naval Research (ONR) in Arlington, Va., issued a request for information last month (N00014-16-RFI-0001) for the electro-optical Imaging Through Obscurants project, which seeks to deal with fog, haze, rain, and snow, but not with dust or smoke.

Navy vessels often must operate in congested waterways throughout the world, where they must use electro-optical (EO) and infrared (IR) sensors for situational awareness and target detection, tracking, and identification. The short wavelengths of EO/IR sensors, however, make imaging far more susceptible to performance degradation from the scattering of water-based aerosols. Imaging through dense fog is the intrinsic hard problem, researchers say.

To deal with these problems, ONR officials are considering sensor post processing that uses prior information about the scene, as well as overcoming limitations that scattering water-based aerosols impose on the signal-to-background ratio of EO/IR sensors.

Researchers are interested in active imaging techniques with approaches like structured laser-light illumination and temporal gating.



Fog has been the bane of mariners for millennia. Now Navy researchers are trying to develop electro-optical sensors that can penetrate through fog, haze, rain, and snow at sea.

Navy experts also are interested in passive imaging techniques that use a judicious choice of spectral bands, polarization diversity, high-speed multi-frame acquisition, or other mode of acquisition together with advanced signal processing.

Proposed solutions may involve spectroscopic properties of obscurants, and use all or any portion of the electromagnetic spectrum ranging from the ultraviolet to the far infrared, including visible light, near-infrared, shortwave infrared (SWIR), midwave infrared (MWIR), and longwave infrared (LWIR). Researchers say they are not interested in millimeter-wave solutions.

Companies interested were to e-mail ideas no later than 19 Feb. 2016 to the Navy's Ravi Athale at ravindra.athale@navy.mil with "RFI: Imaging through Obscurants" in the subject line. E-mail questions to Athale at the above address.

MORE INFORMATION IS online at *https://www.fbo.gov/spg/DON/ONR/ONR/N00014-16-RFI-0001/listing.html*.

Army to brief industry on computing, power, EW, and intelligence technologies

U.S. Army researchers will brief industry on potential contracting opportunities at the Army Communications-Electronics Research, Development, and Engineering Center from 31 March to 1 April 2016 at Aberdeen Proving Ground, Md. Briefings will focus on enabling technologies for command, power, and integration; intelligence and information warfare; night vision; space and terrestrial applications; and other special topics. Sessions will provide strategic perspectives and insights into CERDEC's current science and technology roadmaps in advanced computing platforms, software architectures, and visualization systems; soldier and mobile power and energy; capabilities that protect the network and deny or manipulate information for intelligence protection; electronic warfare (EW) to sense, protect, and control the electromagnetic spectrum dynamically and deny its use by adversaries; intelligence, surveillance, reconnaissance, and targeting information collection that adapts to changes and narrows focus on signatures of interest; intelligence analysis, exploitation and dissemination; technologies to detect, identify, and defeat improvised explosive devices and other explosives; and networking technologies to transport and analyze data from numerous Army, joint, and coalition sources. E-mail questions to john.r.lambert1.civ@mail.mil or james.a.greer.civ@mail.mil.

PRODUCT applications

COUNTER-IED

Sierra Nevada helps Marines counter roadside bombs, enemy communications

Sierra Nevada Corp. in Sparks, Nev., won a $73.2 million U.S. Marine Corps contract to provide Marine Expeditionary Units with the Sierra Nevada Modi II backpack electronic warfare (EW) system to defeat improvised explosive devices (IEDs) and disrupt enemy communications on the battlefield.

The order is for 581 systems, including spares and training. Sierra Nevada's EW products are fielded to protect U.S. and allied forces against radio-controlled improvised explosive devices (RCIEDs).

The Modi II represents an evolution of the company's Thor II/AN PLT-5 and Thor III AN/PLQ-9. The AN/PLT-5 man-packable ECM system, known as Thor II, was developed for joint Explosive Ordnance Disposal forces and AN/PLQ-9 was developed for joint conventional forces.

Sierra Nevada's EW software-definable EW systems are configured for backpack), vehicular, fixed-site, and airborne applications. The Modi II system is a potential multifunction, networked, military system-of-systems architecture.

FOR MORE INFORMATION visit **Sierra Nevada** online at *www.sncorp.com*.

CYBER SECURITY

ViaSat to develop embedded crypto for military handhelds

U.S. Air Force information security experts needed advanced embedded cryptography capability for small, lightweight military handheld devices that handle sensitive and classified data. They found their solution from ViaSat Inc. in Carlsbad, Calif.

Officials of the Air Force Life Cycle Management Center at Joint Base San Antonio, Texas, announced a $13.2 million, five-year contract to ViaSat for the Mini Crypto program, which seeks to develop embedded cryptographic capability for handheld tactical devices with integrated National Security Agency (NSA) tenets.

Mini Crypto is a small, low-power, self-contained cryptographic module that can be embedded in a variety of communication devices to protect data and ensure the authentication of those communicating with it. The Mini Crypto program will secure

information sharing not only for U.S. Department of Defense (DOD) operations, but also with coalition partners and friendly forces.

Many modern warfighting devices on the battlefield are small, lightweight, and power-efficient, and support sensitive and classified data that must be protected. Modern warfighting missions require key management for mission-time generation and over-the-air distribution of crypto keys to tactical devices. Without a cryptographic solution in tactical devices, communications may be vulnerable to compromise and exploitation. The Mini Crypto program seeks to develop and build embedded cryptographic capability for size, weight, and power (SWaP)-constrained tactical devices that require NSA-mandated data security.

ViaSat will handle full-scale development, low-rate initial production, and full-scale production by designing, developing, building, and integrating all Mini Crypto Modules, including hardware and software. Initially, ViaSat will develop and deliver four prototypes to demonstrate limited capabilities of the Mini Crypto module, as well as three emulators to develop functionalities and interfaces to help with systems integration.

FOR MORE INFORMATION visit **ViaSat** online at *www.viasat.com*.

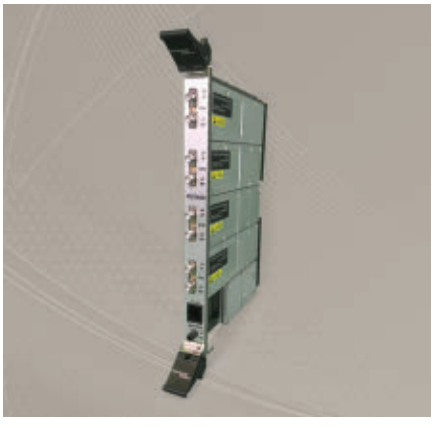
new PRODUCTS

To submit new products for consideration, contact John Keller at jkeller@pennwell.com.

RF AND MICROWAVE

Microwave tuner for 0.5 to 20 GHz introduced by Rockwell Collins

Rockwell Collins in Cedar Rapids, Iowa, is introducing the RC-8800 multi-channel microwave tuner for military and aerospace RF and microwave applications. The RC-8800 multi-channel microwave tuner ac-



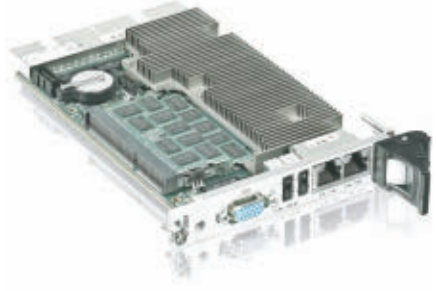
cepts radio frequency inputs from 0.5 to 20 GHz, providing multiple bandwidth intermediate frequency (IF) outputs for downstream processing. The RF and microwave device can be configured with up to four channels in a single slot. The high dynamic range channels can be tuned independently or together to serve as one high-probability-of-intercept system. The Rockwell Collins digital architecture centers on an embedded reconfigurable field programmable gate array (FPGA) and high-speed memory, allowing for fast response, feature development, and product enhancements. Software supports open system architectures.

FOR MORE INFORMATION visit **Rockwell Collins** online at *www.rockwellcollins.com*.

EMBEDDED COMPUTING

3U CompactPCI board for military uses introduced by Kontron

Kontron in Augsburg, Germany, is introducing the CP3004-SA CompactPCI embedded computing board for military and aerospace, industrial automation, coal, oil, and gas applications. The CP3004-SA is a 3U CompactPCI blade based on the 5th Gen Intel Core i7 processor and the 4th Gen Intel Core i5 and i3 processors. The dual-core versions provide for low heat dissipation. Moreover, all cores have the capability for dynamic adjustment of the thermal design power (TDP), to maintain a temperature limit needed in certain environments. These cores alone provide



increased performance-per-watt, enhanced and accelerated floating-point calculation, and high-end graphics. The CompactPCI modular form factor is designed for high reliability and long-term programs, as well as demanding environments.

FOR MORE INFORMATION visit **Kontron** online at *www.kontron.com*.

RF AND MICROWAVE

Digital RF signal boosters introduced by Bird Technologies

Bird Technologies is introducing the 614 series digital RF signal

boosters for stadiums, airports, office buildings, hospitals, tunnels, and any place lacking adequate signal coverage. The RF and microwave signal boosters are designed to increase the signal strength of land-mobile and public safety communications systems operating at either 450 to 470 MHz or 470 MHz to 488 MHz. The configurable system combines programmable digital RF filters, the cryptographic and other security benefits of the SNMPv3 control protocol, browser-based configuration and management, and the ability to view changes to filter characteristics while viewing their effects in real-time. The rugged 614 series signal boosters are housed in NEMA 4 type enclosures, and are certified to meet FCC and Industry Canada certifications as either Class A or Class B boosters depending on their configuration. ←

FOR MORE INFORMATION visit **Bird Technologies** online at *www.birdrf.com*.

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