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Pushing Expeditionary Efficiency
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Maximizing Energy Resiliency
By Kevin Hunter

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Cover: Fuel Formation

The guided-missile destroyer USS Stout prepares to receive fuel from the fast combat support ship USNS Arctic during a replenishment in the Persian Gulf. The Stout is supporting maritime security operations and theater security cooperation efforts in the U.S. 5th Fleet area of operations.
(Navy photo by Petty Officer 3rd Class Bill Dodge)

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The Navy's Freedom-class and Independence-class Littoral Combat Ships combine aviation assets to deploy manned and unmanned vehicles and sensors in support of mine countermeasures, anti-submarine warfare, or surface warfare missions.
By Christian Sheehy
As threats to American interests around the globe have become more numerous, so have the capabilities that comprise the readiness of naval assets which protect these interests from off shore. From challenges to maintaining territorial waters security to threats posed from vast international domains, the measured use of technology and the fuel needed to power that technology is more critical than ever to the sustainability of fleet potency in the face of uncertain amorphous global maritime boundaries.

Tactical Defense Media is proud to present the inaugural issue of Naval Power & Force Projection (NP&FP), a publication dedicated to addressing key issues at the fore of current operational requirements from a balanced, objective viewpoint. Within the pages to follow, we hope to provide readers with targeted perspectives on the state of fleet readiness from interviews with decision makers in arenas such as energy management, unmanned systems application, manned air assets, and new and active hull replacement including Marine Corps amphibious fleet and Navy Littoral Combat Ship (LCS) program production. On the power front, NP&FP offers interviews with leaders from the Office of the Assistant Secretary of Defense for Energy, Installations and Environment Ms. Amanda Simpson, U.S. Navy Energy Office Mr. Joe Bryan, and U.S. Defense Logistics Agency-Energy BG Martin Chapin, on challenges both shared and unique to the energy demands of each segment of U.S. defense.

Looking to the skies, today's complex naval readiness environment is seemingly as much about capability from the air as it is from the sea. The state of U.S. Naval Air (NAVAIR) assets from the new electronic Consolidated Automated Support System (eCASS) for rapid repair and support of airframes to performance-based logistics partnering for coordinated supply chain management. From manned air to unmanned air, land, and sea, NP&FP explores U.S. Marine Corps efforts to maximize requirements for current and future combined arms maneuver across an increasingly complex battlespace. Recent innovations in ground control unmanned air system (UAS) sensor technology are enabling greater authority over operation and controller-asset communication in counter-unmanned UAS evaluation. From below the waves, a new unmanned undersea vehicle (UUV) asset touting electric-drive fuel cell-enabled propulsion based off many of today's commercial auto designs may be on the near horizon.

Not to be remiss on the longer term, NP&FP could not be prouder to offer readers insight from the eyes of retired Rear Admiral Sinclair Harris, Vice President for Business Development, LMI, regarding his views on how the complexity of future geopolitical scenarios and policy decisions of a new U.S. administration may be the catalyst for a higher demand in use of naval forces and maritime assets to support America's strategic aims.

We look forward to your comments! Enjoy and Happy New Year!

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MAINTAINING PRECISION AIR SUPPORT READINESS


Interview conducted by TDM Editors Kevin Hunter and Scott Sharon

NP&FP: What needs by NAVAIR existed that helped give rise to CASS (Consolidated Automated Support System)?

CAPT Jacobs: Aircraft operational readiness is one of the most important metrics to the naval aviation Sailor and Marine Fleet operators. Having a repair capability near the Navy and Marine aircraft at the Intermediate Maintenance Level (I-Level) enables quick repair of failed aircraft assemblies. This Automatic Test Equipment (ATE) is critical in providing rapid repair support for electronics/avionics weapon systems.

ATE is an electronics test system used to test complex electronics/avionics weapon systems “black boxes” and circuit card assemblies during the maintenance process. ATE is a hardware and software integration of mostly commercial stimulus and measurement test instruments into a test system capable of automatic testing of failed weapon system assemblies. The ATE provides test stimulus to these assemblies and measures results for diagnosing failures and end to end testing to assure that the weapon system assemblies are Ready For Issue (RFI) back into the aircraft. The Navy’s Fleet ATE is operated and maintained by Sailors and Marines.

Naval aviation’s common ATE program is the Consolidated Automated Support System (CASS) Family of Testers (FoT). There currently are three generations of the CASS FoT as depicted in Figure (1).

Each generation comprises multiple station configurations that provide automatic test capability for Communications, RADAR, Electronic Warfare, Electro Optical, and other electronics/avionics systems requiring a wide range of test capability ranging from DC to light frequencies. The original “Mainframe” CASS generation was fielded in the early 1990s comprising five related station configurations. The Reconfigurable Transportable CASS (RTCASS) was fielded for the Marine Corps starting in 2009 providing a more easily transportable test capability and more recently adding a configuration for improved circuit card assembly testing at Depots. The Electronic CASS (eCASS) is a replacement program for the aging Mainframe CASS stations. eCASS will begin replacing CASS at the I-Level with Initial Operational Capability (IOC) in late 2017 and reach Full Operational Capability (FOC) in 2025. While CASS was planned for a 20 year life cycle, it will be providing service for over 34 years. eCASS will continue supporting the full range of current/future Navy and Marine Corps aircraft.

A Test Program Set (TPS) is the hardware, instructions, and the test program (computer program) needed for interfacing and testing a specific weapon system assembly to the ATE. There are over 1,000 CASS TPSs in the inventory. Running a TPS on a CASS FoT test station can take from just a few minutes to test a circuit card to over 10 hours for the most complex electronics weapon systems assemblies. Each new generation of the CASS FoT is designed to allow easy “migration” and re-use of the legacy weapon system TPSs to the new generation to conserve the Navy’s $2B investment in CASS FoT legacy TPSs. New TPSs continue to be developed as aircraft systems are upgraded and new aircraft platforms enter the Naval Aviation inventory. TPSs are retired as the aircraft platform that they support retires.

The CASS FoT are deployed on the large and small aircraft carriers, at shore I-Level sites, in Marine Mobile Maintenance Facilities, in Navy and industry labs, and at DoD Depots. A large shore based Navy I-Level site currently has about 30 CASS stations of various configurations while a nuclear powered aircraft carrier will have about 16 CASS stations on board.

NP&FP: How and where has CASS been most effective in complementing the Navy’s air support command?

Mr. Hansard: During the 1980s the Navy became burdened with many types of ATE needed to support its aviation programs. At that time a typical aircraft carrier deployed with 45 ATE stations made up of 30 different types. Many of the aircraft program offices acquired and deployed their own unique ATE.

In the mid-1980s, NAVAIR initiated a standard common ATE program that became the CASS FoT program. The program included the “re-hosting” of the test programs for over 1,500 electronics/avionics “Black Boxes” and circuit cards from about 30 different legacy ATE to the CASS FoT. Figure (2) notes some of the benefits of moving from 30 different ATE to one common family of ATE.

The CASS FoT approach resulted in a 20-year $3.8B Reduced Total Ownership Costs to the Navy and the U.S. taxpayers while providing the tremendous logistics advantage noted between the boxes in Figure (2). The NEC (Navy Enlisted Classification) represents the training tracks needed for the Sailors and Marines – a reduction from 41 different training tracks to five with the CASS FoT. Also note the tremendous number of ATE spare parts no longer needed. Not shown in these two boxes is the cost avoidance from now requiring only one engineering and logistics support team for the CASS FoT vs. 30 different support teams as previously required. It is important to note that with the CASS FoT approach, the weapon system assembly test programs within the TPSs are all in the same set of programing environments vs. 30 different environments with the legacy ATE. This
significantly reduces the engineering and test effort needed as the CASS FoT moves from one generation to the next generation. Moving hundreds of TPSs from one generation CASS FoT to the next is a “migration” through translation vs. “re-hosting” TPSs by re-writing the test program code.

The avionics test and repair capability afforded by the nearby presence of the CASS FoT contributes to aircraft readiness and avoids the need to fly a failed asset back to a Depot for repair. This allows quick return of failed aircraft assets to make an aircraft mission ready and reduces the number of high cost avionics system spares needed for the repair cycle. The cost avoidance to the Fleet for not returning failed assets to the Depot is $1.2B annually.

NP&FP: In regard to electronic Consolidated Automated Support System (eCASS), talk about industry cooperation with NAVAIR regarding the process of prototype to fielding.

Mr. Demme: While the RTCASS was provided by Boeing, the CASS and its replacement eCASS, are both provided by Lockheed Martin Rotary and Mission Systems (RMS). The Navy’s CASS FoT technical and logistics teams work as an integrated team with Boeing and Lockheed during development, test, and sustainment for the CASS, RTCASS, and eCASS test systems.

The third generation CASS FoT is the eCASS which is completing its development and test phases and expected to enter full rate production by the end of calendar year 2016.

The eCASS development program has continued to be an integrated Navy and Lockheed Martin effort. Subject matter experts from the Navy’s CASS FoT technical team have been assigned to work side-by-side with their industry counterparts, including instrumentation and weapon system OEMs, in the Lockheed Martin labs nearly constantly since eCASS system integration began with the Engineering Development Models (EDMs) four years ago. This collaborative work environment has continued through the various phases of Developmental Testing and provided timely cost effective technical solutions that have helped keep the program on-track to reach Initial Operational Capability (IOC) in late 2017.

To date, three Limited Rate Initial Production (LRIP) lot orders have been placed for a total of 67 eCASS stations. These stations are being used to complete test and evaluation and for the “migration” of about 550 CASS TPSs to the eCASS test system. The TPS “migration” effort is being conducted at five Navy sites and Boeing, St. Louis concurrent with eCASS LRIP efforts at Lockheed Martin RMS, Orlando.

Since 2008, the Navy and its international partners’ CASS stations have been supported by a Performance Based Logistics (PBL) contract with Lockheed Martin RMS. The PBL contract provides Depot level support of repairable components, calibration, and obsolescence management. The Lockheed Martin contract has maintained an availability of over 90 percent of its Fleet CASS stations. In 2009 the joint Navy/Lockheed Martin RMS CASS PBL team received the “Secretary of Defense Outstanding PBL Award.” In May 2016, a new 7-year PBL contract was awarded to Lockheed Martin RMS who has teamed with Boeing for support of both the CASS and RTCASS programs. As failure history data comes available for eCASS, the Navy will consider a future PBL contract that would leverage across CASS, RTCASS, and eCASS for optimum repair cost efficiency.

The CASS FoT will continue to help keep Fleet aircraft operationally ready, as the program expands to embrace new aircraft programs like P-8, H-53K and F-35.
U.S. Naval assessments call for no fewer than 38 survivable, capable amphibious warships, a minimum number allowing the service to project combat power from ship-to-shore and inland, globally.

"Today we need 38 amphibious, gray-hulled ships to do combat. To do the business of the world today, we'd need 50 ships to do humanitarian assistance," Chief Naval Officer (CNO) ADM Jonathan Greenert testified during a 2015 House Defense Appropriations Subcommittee.

Needs aside, the sea service has only 30 active amphibious warships, too few to satisfy USMC transport requirements. An issue compelling the Marine Corps to explore options using foreign vessels to transport smaller company-sized units, accompanied by up to four MV-22 Osprey tilt-rotor aircraft.

The Corp’s deployments traditionally consist of far larger reinforced infantry battalion sized expeditionary units calling for thousands of personnel, Navy and Marine along with an air component including MV-22 and MH-53E transports, AH-1W/Z attack helicopters and AV-8B Harrier strike aircraft, soon to be replaced by the F-35B Joint Strike Fighter.

Hitching An Allied Ride

As part of the 2015 USMC Allied Basing Initiative, the service is conducting experiments to determine if deploying smaller numbers of troops, approximately 100, from ships of North Atlantic Treaty Organization (NATO) allies could be a realistic work around to the shortage of U.S. amphibious lift, one not likely to be resolved until the mid-2020 timeframe.

Evaluations include amphibious warships from navies of France, Italy, The Netherlands and the United Kingdom. Determining if MV-22 flight operations are possible from allied ships, given the aircraft's stringent landing deck requirements, are of high importance.

While it is clear U.S. Congressional leadership understands the need for amphibious shipping as evidenced by the authorization and funding for a 12th San Antonio class amphibious transport dock (LPD 28), the addition of a single hull will not improve the overall shortage and could result in a reduction of any San Antonio class follow-on transport.

Force Balance: 30 - 34 - 38?

Responding to queries from Naval Power & Force Projection regarding near term amphibious shipping inventory goals, U.S. Navy spokesperson Lt. Meagan Shulka responded, "The 34 ship force accepts risk in the arrival of combat support and combat service support elements of a Marine Expeditionary Brigade, adjudged as adequately meeting naval service needs. Understanding the overall lift requirement for 38 total amphibious assault ships, and
in light of the fiscal constraints, operating a minimum inventory of 34 total amphibious ships is the current target.”

Presently, the Navy’s amphibious inventory consists of four types, 12 Landing Ship Dock (LSD), nine Amphibious Transport Dock (LPD), one Amphibious Assault Ship - General Purpose (LHA) and eight Multi-Purpose Amphibious Assault Ships (LHD).

**Whidbey Island Seniors**

Commissioned between 1985 and 1992, eight Whidbey Island class landing ship dock (LSD) are the Navy’s longest serving. These ships can transport 400 troops under normal conditions, up to 500 for surge requirements. Designed with flood-able dock space, the class was acquired to transport and launch up to four Landing Craft Air Cushion (LCAC). Aviation facilities are limited to landing deck space for two medium helicopters.

Completing a mid-life upgrade in 2015, Whidbey Island class hulls 41-47 will remain in service until 2038, slowly phased out over time.

Lacking command and control, medical and aviation facilities to support sustained combat operations ashore, the class was not intended to conduct and support independent landings without the presence of additional assets.

A follow-on build of four Harpers Ferry class LSD, essentially the Whidbey Island design with increased cargo capacity were commissioned from 1995-98. The class is differentiated by increased storage in the well deck area. Only two LCAC ship-to-shore connectors can be transported and operated.

**San Antonio Dozen**

As noted, a 12th San Antonio class amphibious transport dock (LPD) was authorized by the U.S. Congress. Presently two hulls, LPD 26 and LPD 27 are under construction at Huntington Ingalls Industries. Deliveries are planned for 2016 and 2017 respectively, according to the information provided by the Navy.

Better suited for independent operations, also known as the split-ARG (amphibious ready group), the San Antonio class can transport and land up to 800 troops. Two LCAC may be carried; alternatively, a mix of amphibious assault vehicles and ship-to-shore connectors such as landing craft utility (LCU) may be used.

Up to four helicopters are supported with hanger space for two. Advanced medical and command and control facilities support smaller landing operations, eliminating the need for additional assets when conducting missions limited in scope.

**Sting of the Wasp**

Eight Wasp class amphibious assault ships, commissioned from 1989-2009 are perhaps the most capable in the fleet. Planned modifications will enable the type to operate F-35B JSF and MV-22 transports. The class can transport and land up to 1,900 troops and equipment comprising a reinforced Marine infantry battalion, a formation including artillery, light armored vehicles, and main battle tanks.

The Wasp class well deck configuration has space for three LCACs. Nine flight deck
Wrong-Sized for USMC Forward Presence Goals

Deploying small numbers of Marines and aircraft from large deck amphibious ships is not cost effective, regardless of amphibious asset availability.

Conducting combat operations from the sea, however limited, requires support assets, medical, command and control and supply. Given the high technology and support requirements for the MV-22, proper aircraft maintenance facilities are a necessity for deployments of any significant duration.

As the Navy’s Small Surface Combatant Task Force explores a solution to replace the final 20 hulls of the cancelled Littoral Combat Ship, Marine Corps leaders should provide input on how frigate type designs being considered may be configured to provide transport for smaller Marine modules.

Dock Landing Ship - LSD

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<tr>
<th>Whidbey Island Class (8 Total)</th>
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<tbody>
<tr>
<td>USS Whidbey Island (LSD 41), Little Creek, VA</td>
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<tr>
<td>USS Germantown (LSD 42), Sasebo, Japan</td>
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<tr>
<td>USS Fort McHenry (LSD 43), Mayport, FL</td>
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<td>USS Gunston Hall (LSD 44), Little Creek, VA</td>
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<td>USS Comstock (LSD 45), San Diego, CA</td>
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<td>USS Tortuga (LSD 46), Little Creek, VA</td>
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<tr>
<td>USS Rushmore (LSD 47), San Diego, CA</td>
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<td>USS Ashland (LSD 48), Sasebo, Japan</td>
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<th>Harpers Ferry Class (4 Total)</th>
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<tr>
<td>USS Harpers Ferry (LSD 49), San Diego, CA</td>
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<tr>
<td>USS Carter Hall (LSD 50), Little Creek, VA</td>
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<tr>
<td>USS Oak Hill (LSD 51), Little Creek, VA</td>
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<tr>
<td>USS Pearl Harbor (LSD 52), San Diego, CA</td>
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The Navy plans to begin replacement of the Whidbey Island class in 2020 with the LR(X), a design based on the LPD 17 San Antonio class hull.

Amphibious Transport Dock-LPD

San Antonio Class (9 Total)

USS San Antonio (LPD 17), Norfolk, VA
USS New Orleans (LPD 18), San Diego, CA
USS Mesa Verde (LPD 19), Norfolk, VA
USS Green Bay (LPD 20), San Diego, CA
USS New York (LPD 21), Norfolk, VA
USS San Diego (LPD 22), San Diego, CA
USS Anchorage (LPD 23), San Diego
USS Arlington (LPD 24), Norfolk, VA
USS Somerset (LPD 25), San Diego, CA

USS John P. Murtha (LPD 26) in service in August 2016 and commissioned in October

USS Portland (LPD 27) under construction, anticipated delivery in 2017

Funding for construction of 12th San Antonio class (LPD 28) was authorized in 2014 and included in the Navy’s FY2016 budget

Amphibious Assault Ship, General Purpose - LHA

America Class (1 Total)

USS America (LHA 6), San Diego, CA

USN Amphibious Ship Inventory

Navy spokesperson Lt. Shulka provided Naval Power & Force Projection with an up to date list of amphibious warships ships now in active service. Ship name, pennant number and home port are listed.

Note: the Navy has ships used to deliver equipment and troops ashore, these are not considered true amphibious warships, and, as such are not included below:

Pacific Tilting Amphibs?... Navy’s Not Telling

The Navy’s amphibious inventory will remain as currently deployed, according to Lt. Shulka.

“The Asia-Pacific Rebalance strategy as outlined by CNO Greenert calls for approximately 60 percent of Navy ships and aircraft to be based in the Pacific region by 2020, we were at about 57 percent in 2013 and we’ll continue that evolution through this decade.”

Shulka noted the service will maintain a Carrier Strike Group, Carrier Air Wing, and Amphibious Ready Group in Japan, however, due to operational security, would not comment on specific future movements regarding fleet assets.
LED shipboard lighting, one of the critical energy conservation measures to be employed by the Great Green Fleet, is not only saving the U.S. Navy critical resources while underway, it is also reducing shore side power consumption in port. Underway, LED lighting enables enhanced readiness through reduced maintenance, reduced fuel requirements, and freed up energy resources which can be directed to other requirements, such as next-generation energy-intensive weapons systems. While in port, shipboard LEDs contribute to installation energy requirements and reduced energy bills. Given that the Navy’s fiscal year 2015 expenditure for installation energy consumption was roughly $1.1 billion, according to the Department of Defense Annual Energy Management Report. Consequently, every dollar saved ashore can be put to use supporting other critical requirements.

As the former Commanding Officer NAVFAC Mid-Atlantic, Mr. Libonate joined ADS in 2014 and is responsible for the execution of strategic company initiatives and implementation into the market teams. Prior to joining ADS, he served in the United States Navy Civil Engineer Corps officer. His Naval career highlights include serving as Chief of Staff, Naval Facilities Engineering Command (NAVFAC) and three command tours: NAVFAC Mid-Atlantic, Naval Mobile Construction Battalion 74 and Construction Battalion Maintenance Unit 302. Mr. Libonate is a Professional Engineer registered in the Commonwealth of Virginia, and earned a M.S.E. in Civil Engineering from the University of Texas at Austin and a B.S. in Naval Architecture from the United States Naval Academy.
Joseph M. Bryan was appointed as Deputy Assistant Secretary of the Navy for Energy in November 2014. Mr. Bryan serves as the Secretariat focal point on all matters pertaining to the Department of Navy’s energy initiatives.

Mr. Bryan joined the Department of the Navy from the United States Senate where he served in several professional staff roles. Most recently, Mr. Bryan was the Investigations Team Lead for the Committee on Armed Services. During his tenure, the committee completed investigations into cyber intrusions affecting U.S. Transportation Command contractors, U.S. costs and allied contributions to support the U.S. military presence overseas, the presence of counterfeit electronic parts in the military supply chain, the use of private security contractors in Afghanistan, and the treatment of detainees in U.S. custody.

From 2005 to January 2007, Mr. Bryan served on the Select Committee on Intelligence, where he advised Senator Carl Levin on legal, policy, and programmatic issues affecting the U.S. Intelligence Community. He also represented Senator Levin in legislative negotiations and investigations into pre-Iraq war intelligence.

From 2001 to April 2005, he was responsible for legislative issues related to Senate Judiciary and Governmental Affairs Committees, including judicial nominations, criminal justice, legal reform, and federal employees.

Earlier in his career, Mr. Bryan worked at the University of Cape Town’s Energy and Development Research Center, Cape Town, South Africa. In this position, he coordinated research and briefings for Chairman of the South African Parliamentary Portfolio Committee on Minerals and Energy on the development and regulation of domestic energy industries. He also advised Namibian Ministry of Minerals and Energy on the development of a white paper to guide development of national energy policy.

Mr. Bryan received a Bachelor of Arts degree in 1991 from Fordham University and a Master of Arts from the University of Delaware in Urban Affairs and Public Policy, with a focus on energy and environmental policy.

Interview conducted by DoD P&E Editor Kevin Hunter

DoD Power & Energy had the recent pleasure of speaking with Mr. Joe Bryan, Deputy Assistant Secretary of the Navy for Energy, regarding Navy and Marine Corps efforts to transform current trends in energy usage for maximizing operational capability and force projection.

DoD P&E: Please provide some insight as to primary focus areas at DASN mid 2016 forward.

Mr. Bryan: Six and a half years ago, in a speech at the Naval Energy Forum, Secretary Mabus announced some very aggressive energy goals. He said that the Department of the Navy would get 50 percent of our energy from alternative sources by 2020: that we would get 50 percent of our shore energy from alternative sources by 2020. He said we’d reduce fuel consumption in our non-tactical vehicle fleet by 50 percent; and that we’d sail the Great Green Fleet.

He did this because increasing energy efficiency and diversifying our energy supply make us better at our job. The bottom line is that we are transforming how the Navy and Marine Corps use energy so that we can go further on a tank of gas, we can stay there longer, and we can deliver more firepower when we’re there. That’s the mission.

In the years since Secretary Mabus set these goals, we have made great progress. We have over 1 gigawatt of renewable energy for our bases either under contract or in procurement, and we have certified all our platforms to operate on alternative fuels. In January, we launched the Great Green Fleet and deployed a Carrier Strike Group running on an alternative fuel blend made from Midwest beef fat. Throughout the Navy and Marine Corps, Sailors and Marines are developing new ways of doing their jobs using energy more efficiently, and we are partnering with industry and academia to drive innovations in how we think about and use energy.

In the fleet, we are working to make our ships as efficient as possible, so that we increase time underway instead of tied to oilers. This includes plans to install Hybrid Propulsion Systems in Arleigh Burke-class guided missile destroyers, enabling our ships to conserve fuel at lower speeds, so it’s available when they really need it.

Ashore, we are changing the way we think about mobility and - where it makes sense – transitioning to zero emission vehicles.
In January we issued a solicitation for up to 400 electric vehicles for use on our California installations. We look forward to seeing if the private sector can deliver our requirement at a competitive price.

Throughout the rest of 2016, and continuing in 2017 and beyond, we will continue to look at new ways to transform our energy use to make us better warfighters.

**DoD P&E: From a Navy fleet-wide perspective, please speak to some key areas of focus and challenges associated with them.**

Mr. Bryan: Assistant Secretary McGinn likes to say that although there’s no silver bullet when it comes to energy efficiency, there is silver buckshot. That is to say, there is no innovation or adjustment too small to implement, and when we combine our efforts we can achieve impressive results. For example, we are installing LED lights aboard ships to cut ship electrical demand and reduce maintenance time. Not only that, but LEDs improve the quality of light for sailors.

Ships are also using operational procedures like trail shaft, drift operations, autopilot, and duty radar to increase energy efficiency. On a cruiser, running on trail shaft can save thousands of gallons of fuel per day, enabling the ship to stay on station longer or have more fuel for maneuverability. Minimizing bleed air use improves engine efficiency and gives a ship additional underway hours over the course of a year.

We are diversifying our fuel sources to improve operational flexibility. In September 2015, the Defense Logistics Agency awarded a contract for 77 million gallons of an alternative fuel blend produced by a California-based company. The alternative fuel portion of the blend was made from beef fat from farmers in the midwestern United States. Since January, the Stennis Carrier Strike Group and other ships operating in the Pacific have, at various times, used the alternative fuel during the course of their normal operations. In July, USN ships and those of many of our allies will use the same alternative fuel blend during the Rim of the Pacific exercise, the largest maritime exercise in the world.

We are also focused on building energy resiliency on our installations. You cannot draw a bright line between our shore installations and forward operations. The fact is that our bases are critical to generating the force structure we need to project power and increasingly provide direct support to forward operations.

If power to our installations is vulnerable – so is the mission. In 2014, Secretary Mabus stood up the Renewable Energy Program Office which was charged with deploying renewable energy to make sure that the lights stay on and operations continue even when the commercial grid goes down. In less than two years, the REPO team has gotten over 1 gigawatt of renewable energy capacity under contract or into the procurement pipeline. That’s enough energy to power 14 Arleigh Burke-class destroyers or 250,000 homes.

**DoD P&E: From a USMC perspective, please speak to ways DASN is facilitating efforts to improve expeditionary energy usage.**

Mr. Bryan: According to one study, one Marine was killed or wounded in Afghanistan for every 50 fuel and water truck convoys. Cutting fuel use can help take fuel trucks off the road and extend the operational reach of the force. Marines now deploy with solar energy systems to power their radios, communications equipment, and other gear. The Marine Corps’ Expeditionary Energy Office is working hard to increase energy efficiency and reduce demand for liquid fuel. This includes developing technology to improve the fuel efficiency of Medium Duty Tactical Vehicles – the workhorse of the tactical fleet – and combining solar panels with diesel generators to reduce fuel use at the tactical edge.

**DoD P&E: From an industry partnering perspective, how is DASN working to partner with civilian facilities to broaden and strengthen actual implementation efforts?**

Mr. Bryan: We know that to maintain our leadership role, we need to innovate. Secretary Mabus and Assistant Secretary McGinn both stress how important it is to our innovation efforts that we build partnerships with academia and the private sector.

One example of how we are partnering with academia is the Naval Enterprise Partnership Teaming with Universities for National Excellence (NEPTUNE) initiative. This two-year pilot program provides funding to four universities, the U.S. Naval Academy, and the Naval Postgraduate School. Its goal is to help the Navy and Marine Corps discover ways to improve energy conservation, generate renewable energy, and implement energy-efficient technologies, while giving active-duty service members, military students and veterans the chance to get involved in university-level research.

Our energy successes depend on strong and diverse partnerships with the private sector. The REPO team’s partnerships with utilities and project developers have been instrumental in the development of new business models for cost effective large-scale renewable energy projects. We are also working closely with the private sector to improve the energy efficiency of our installations. In fact, we currently have $1.3 billion in energy saving performance contracts in the pipeline.

**DoD P&E: Please speak to any other challenges DASN is addressing going forward.**

Mr. Bryan: Changing the culture of the Navy and Marine Corps to view energy efficiency and alternative energy as priorities is a critical challenge. While we have a strong history as energy innovators, just like in any large organization, change can come slowly. Both Services have developed initiatives to educate and inform Sailors and Marines how energy is crucial to the mission. The Navy’s Energy Warrior program is targeted towards deck plate sailors, enabling them to learn about the need for energy efficiency and share innovations they develop. The Marine Corps has developed an “Energy Ethos” campaign that promotes the shared vision that the efficient use of energy resources is a critical component of mission readiness.

Another challenge is adapting our acquisition processes to accommodate innovation. Technology is changing faster than ever and maintaining our edge depends on us improving the speed and flexibility of our system.
DoD P&E: Published earlier this year, the new Operational Energy Strategy marked a significant shift over the initial strategy from five years ago. Can you speak to this?

Ms. Simpson: Our focus is on the effectiveness of our military. Reducing our energy use or becoming more efficient is a means to an end, not an end state by itself. Thus, as a fighting force, we aren’t fixated on saving fuel – that is, becoming more efficient – except in those cases where doing so increases our military capability. Likewise, we are continuing to improve our understanding of the risk associated with our need for fuel. The cost that we pay for energy is not the dollar price of fuel. The cost is in the lives and operational opportunities for Soldiers, Sailors, Airmen, and Marines engaging adversaries around the globe. If we’re moving more fuel, we’re spending more material and human capital clearing the routes, protecting the convoys, keeping watch over oilers, or escorting aerial refuelers; if we used less energy, we wouldn’t have to dedicate so much combat power to protecting our supply lines and be able to spend more time directly engaging the enemies of our Nation. We call this the opportunity cost of our dependence on energy. This isn’t about saving dollars or energy. It’s about saving lives and achieving the mission. The challenge here is to marry these concepts together into more capability for the Department.

As we develop new platforms, each one has more capability than the previous, generally a good thing. They’re faster, go further, are more lethal, and more survivable, so that we always have overmatch capability over our adversaries. We pay for this overmatch, however, in our energy needs. For instance, it takes more fuel to move a more heavily protected and capability-driven platform over the same ground as a lighter, less protected and capable variant. So, as we’re looking at the next-generation of capability, what effect will these increased energy requirements have on our ability to sustain forward deployed forces and maneuver against increasing capable adversaries? What does it mean to our supply chains?

In looking at these factors, we’ve identified a disconnect between those who influence the demand side of the curve – operators – and those that are working on the supply side of the equation – logisticians. Unless we can get that discussion between what the users need and what technology is available, we could either be missing an opportunity to take advantage of emerging technology or, conversely, require a capability that is difficult to actually employ, expensive, and could take years to develop.

DoD P&E: How does DoD determine which capabilities are likely to provide the best end result once fielded?

Ms. Simpson: The Joint Capabilities Integration and Development System (JCIDS) process drives all of our requirements. Working with the Joint Staff, we’ve inserted operational energy into our requirements to ensure more capability and less operational risk. There are two steps. First, the program office conducts an Energy Supportability Analysis (ESA). If you’re developing a new capability, the Service proponent must evaluate the energy supportability of the system; that is, how will the future force sustain and operate this system in realistic scenario? For instance, does that mean we’ll need more tankers or oilers, warfighters that carry more batteries, or additional fuel storage and distribution onshore? This analysis ensures that decisions regarding capabilities development are not being made absent of energy knowledge. Taking this information and boiling it down into an energy Key Performance Parameter (eKPP) – the second step – provides a measurable way for the vendor who will build or supply the capability to meet the requirement and be supportable in combat conditions.
We are pushing change across the requirements development process. There’s an understanding that ESAs are helping to field more adaptable, modular systems capable of meeting mission requirements seamlessly within energy availability parameters. In the case of a dismounted unit, for example, it may be as simple as saying we want to use a standardized battery so there’s more flexibility on the battlefield or that new technology allows for better monitoring so that you don’t need to change the batteries as often, or that you have a better understanding of your energy levels before you start an engagement so you can re-charge or change out energy applications proactively.

DoD P&E: From a battlefield energy perspective, U.S. interests are truly global and we don’t get to choose where the next engagement may arise. Does this mean we need to be energy-ready everywhere and, if so, how do we accomplish that?

Ms. Simpson: Much of the work to ensure our readiness is done through analysis of the capabilities and energy demands of our current and projected platforms, and the ability of our systems to satisfy those demands in a realistic environment with the threats presented by our would-be adversaries. Based on lessons learned in U.S. Central Command (CENTCOM), a lot of gear was fielded that was designed for hot desert conditions. However, does a generator work as well in a very cold and dry environment as it might in a hot and dry one, or a hot and humid one? Do we need different systems for different environments or can they be adapted? We are evaluating our current equipment and making sure that future systems will be compatible going forward. That’s going to be a challenge. The Department has made large investments in capabilities across air, sea, and land, and it’s not always possible to immediately replace large swaths of current equipment. Instead, we’re trying to be ready to recapitalize equipment as it wears out with more capable, more energy efficient systems. The Advanced Medium Mobile Power Source (AMMPS), for instance, uses 20% less energy than the worn out Tactical Quiet Generators they’re replacing. In other cases, however, swapping out a new radio or tent may not be feasible because there are so many in the inventory. So, we look for better ways of integrating new technology. Perhaps this is switching out parts during depot or routine maintenance, adding a fly or sunshade to a shelter, and making iterative improvements to an environmental control unit that makes it more efficient for particular weather conditions. A small change in parts can actually result in an impactful change in energy usage. I get concerned, however, regarding the interoperability between systems because occasionally it is effective to make an incremental improvement while a system is fielded. If we buy a widget from vendor A and replacement parts from vendor B, we want to know that we can replace the widget with something from vendor C if they have a better technology in the future without rendering the parts compatibility of vendor A or B obsolete. In short, we want to reduce the need to replace entire systems of systems when only one element of that system needs replacement.

As we see increasing complexity of Joint missions, energy supportability must be factored into operational planning. This means making sure our operation plans, concept plans, and theater engagement plans consider the opportunities and risks of our energy use. As much as we need to buy the right equipment over the long-term, we also need to make sure we optimize the planning and employment of Joint forces in the near- and mid-term. As equipment continues to evolve, so does our energy footprint. In some cases, our energy requirements have increased as our ability to meet this requirement remained flat. These constraints need to be squarely addressed in our operational planning, and mitigations identified, whether that is new equipment, improvements to equipment, partnerships with host countries, or changes in the sequencing and flow of forces.

All of these considerations must be part of our decision-making, from top mission planning echelons down to field commanders. Energy-informed decisions mean more capability and less risk.
Marines from the service’s experimental force, Kilo Company, 3rd Battalion, 5th Marines, deploy a Physical Sciences, Inc. Instant Eye to find threats, gain situational awareness and maintain operational tempo during a recent training exercise. (U.S. Marine Corps)


"On the future battlefield, instead of Marines being the first wave in, it’s unmanned robotics sensing, locating, and possibly neutralizing enemy targets, whether it’s in the air or the surface or subsurface," remarked Walsh. “In the case of air, the Marine Corps seeks a manned fighter such as an F-35B to launch drones before it retreats to act as a digital quarterback in order to maintain crew safety during aerial missions." Walsh said. “Keeping the human pilot out of the worst danger zones while extending his or her influence over much more space by using a large, long-range drone to disperse a swarm of smaller, short-range drones is one possible future scenario.”

Manned-Unmanned Coordination

The U.S. Marine Corps has indicated the need for its amphibious forces to have a complement of robotic systems meant for front-line deployment in an effort to help minimize casualties in future landing operations. One of the key elements for reducing the risk related to these front-line operations of the future that Lt. Gen. Walsh spoke to is Manned and Unmanned Teaming (MUM-T), a key driver in tactical sustainment and re-supply with some reliance on automated systems to “carry the load” for Marines and Joint personnel that may otherwise be in harm’s way. “When you look at MUM-T, there isn’t a whole lot of truly autonomous application that takes personnel “out of the command and control loop,” he said. “Rather than looking at providing more information to another cockpit or on the ground which in essence increases the cognitive burden on the operator, when we talk about MUM-T, we mean the crew of the unmanned system often operating multiple systems simultaneously as part of the solution set for whoever they are supporting,” Walsh added.

The Marine Corps believes automating functions and processes will lead to more effective, collaborative autonomous systems that
will allow its warfighters to remain "heads up" and able to focus on the fight.

"In short, whether manned-unmanned or unmanned-unmanned mission sets, the objective is to reduce the tactical decision-making and management load of employing unmanned systems to enable the Marine operator/s to handle the manned-specific portion of command and control with minimal attention dedicated to the unmanned side," indicated Spataro. "The ultimate goal is to shorten the kill chain to target by increasing situational awareness as much as possible. In electro-magnetic spectrum operations, it's not just for signal intelligence but also for electronic warfare to be able to better sense what's going on in the operating space so you can proactively maneuver within that space. If I have interference or jamming, something impacting my command and control systems, I'm unable to maneuver without the communications necessary to direct that movement and hence promote clear networking," Spataro noted.

From a ground operations perspective, the Marines' Light Armored Reconnaissance (LAR) troops — mounted in eight-wheel-drive armored vehicle called Light Armored Vehicles (LAVs), similar to Army Strykers — locate threats the way the horse cavalry once did, "by running into the enemy." But if a recon patrol launched small drones to scout ahead, Gen. Walsh said, "that is mass we wouldn't be able to have if we were just moving vehicles. The drones could detect enemy radio transmissions, triangulate their location, and then attack by themselves or pass targeting data back to heavier weapons all without a Marine getting in harm's way."

"We've got our LAR battalions out forward, and now they're sensing by running into the enemy," Walsh said. "If we can bring those kinds of unmanned systems where our LAVs are out forward, our reconnaissance units are forward and they can launch their own capabilities, a Low-Cost UAV Swarming Technology (LOCUST)-type capability or lethal munitions that we could send out in the air that can sense, locate different RF signals and then attack those capabilities in advance of where the Marines are, keeping them out of harm's way."

Harnessing Targeted Information

The technology piece of this unmanned systems force integration challenge for the Marine Corps is the use of distributed and connected sensors to enable unmanned systems to do more of the "find and clear" targeting so that Marines can conduct the critical business of destroying enemy assets. Rapid correlation of mass data that has been sensed so that it coalesces into an integrated common operating picture for offensive maneuver is at the heart of the Marine Air Ground Task Force (MAGTF) mission objective. If that integrated data can be drilled down to a low-enough bit rate so that anyone accessing the network has the same operational picture overlayed in a prosecutable interface, combatant commanders' decisions can be concurred with at all levels since they all have the same battlespace awareness. "From that same interface, being able to request fires or other support in scenarios such as unit re-supply is critical," noted Spataro. "The use of unmanned systems to "flatten" the width of command and control at specific locations right as the need is happening by removing as many operator touch points as possible is a real challenge to achieving mission efficiency particularly in long-range maneuver situations."

Intelligence, whether pattern of life, or for specific targets, requires proper authentication to be verifiable as what it is. For example, in cases where obscured environmental conditions exist, synthetic aperture radar (SAR) sensing and moving target indication can be automatically converted into a SAR picture. The less reliance there is on manual processes requiring decisions in locating a target, the more an unmanned application can cross-cue data and provide information back to the operator so they can make informed decisions on a target. In a nutshell, as long as manned controllers operate unmanned systems, or in others words, robots are fighting robots, the challenge will be to better define the decisions required to go from finding to neutralizing a target.

Expeditionary Requirement

"Taking full advantage of the persistent battlespace awareness that only unmanned systems can provide as an element of MUM-T can only happen if you establish integrated common operating command and control through simplified interfaces for decision-makers to affect the battlespace," Spataro pointed out. Communications are a key part of the Corps' Manned-Unmanned Expeditionary (MUX)-dependent operations so that surface, sub-surface, land, and air elements of the fight can coordinate successfully through self-healing mesh type networks, understanding the probability of detection/interception, use of the electro-magnetic spectrum, as well as determining how data can be gleaned from open cyberspace without compromising mission
security. “Tactical use of MUM-T to bridge communications gaps in multi-network operations as only persistent unmanned applications can achieve through a mobile “pseudo” satellite communications construct, is more dependent than ever on network link access where sensor data can be correlated and cross-cued to form a clear picture of the battlespace,” Spataro added.

**Realizing the Future Mission**

The budgetary piece of fulfilling today’s Marine Corps MUM-T mission stems from the structure and manpower that goes into supporting an unmanned system. “There is nothing unmanned about the current MUM-T practices today. Going forward, the majority of MUM-T applications through collaborative sensing and autonomy, will achieve distributed systems where a single crew manages several unmanned systems and are less concerned about flying individual aircraft and more about how their systems support the scheme of maneuver and the Marine, soldier, sailor or airman in action,” Spataro stressed.

“We see swarm-type technology...being able to dominate the battlespace...at a lower cost,” Walsh said. “We find more mass, more affordable, because unmanned systems are going to be less expensive: There’s no human operator inside, by definition, so you don’t have the same need for life-support, reliability, and self-defense.”

As algorithms and software used in commercial unmanned applications becomes more advanced and user interfaces becomes more intuitive, execution of basic functionality to keep the unmanned system moving within its element, be it air, land, or sea, becomes less burdensome, freeing up operators to manipulate combat elements such as communications, targeting, fires, and the command and control big picture in general.

**Short Term and Long**

In the near term, the Marine Corps is determined to invest in enough quadcopter drones to equip four deployed battalions of Marines, Walsh said. Equally significant, to help troops on the ground deal with all this data, the Marines are adding an additional Assistant Squad Leader to every squad. “We don’t want the commander, the squad leader in this case, heads down” looking at a screen,” Walsh noted. “You’ll still need Marines, but they’ll be helped along by a whole lot of cheap robots.”

The Marine Corps Force 2025 has already moved past its Phase I, where potential courses of action were presented to Commandant Gen. Robert Neller to determine how the force could be restructured to be more effective at emerging missions like electronic warfare, cyber warfare, information warfare and more. In the ongoing Phase II, specific decisions regarding how to pay for this future force are being considered. Walsh said it was already clear that a new emphasis on information warfare would require additional resources to go towards unmanned systems and artificial intelligence.
The complexity of future geopolitical scenarios and the policy decisions of the new administration portend a higher demand for the use of naval forces and maritime assets to support America’s strategic aims. Careful analysis and thought is required to ensure that the future fleet is not just larger but also sustainable and interoperable with our partners.

President-elect Donald Trump spoke specifically to the need to build up naval assets in his statement of October 21, 2016: "My plan will build the 350 ship Navy we need. This will be the largest effort at rebuilding our military since Ronald Reagan, and it will require a truly national effort.” I fondly recall the building of the “600-ship Navy” as it precipitated my entry into service, but I also remember that it might not have been the best mix of capabilities, and it certainly had issues in terms of availability and working with allies. As the Navy develops its requirements for fleet structure and architecture, a few key questions come to mind. What ships should be built? What should their specific capabilities be? And how does that fit into the priorities of the nation and our allies?

Three very important (but often forgotten) considerations that should be made as the nation decides on the future fleet are sustainability, logistical support, and interoperability with key allies.

**Fleet sustainability is fundamental**

All of the military services have been under great pressure during the last decade of war and struggled with readiness of the force. Ships have been deployed for longer times and more frequently, causing many maintenance routines to be deferred. To tackle this backlog of maintenance, the Navy implemented an Optimized Fleet Response Plan (O-FRP) in November 2014, with the goal of regaining readiness and to sustain force levels so they are available to support COCOM demands across a full range of military operations. In May 2016, a GAO report suggested that maintenance benchmarks were not being reached, [link to https://news.usni.org/2016/05/03/document-gao-report-on-u-s-navy-optimized-fleet-response-plan] but there should be little doubt that the Fleet Forces Command and OPNAV have made significant progress in addressing readiness issues. Going forward, these maintenance benchmarks and the lessons learned in developing O-FRP must be remembered when planning for the future fleet, no matter what size.

With manpower being one of the largest elements of the Navy budget, there has been a considerable drive to reduce the number of Sailors assigned to ships. My first ship, the Ex-USS Long Beach (CGN 9) required 1,000 crew members to operate and maintain. The USS Zumwalt (DDG 1000) was recently commissioned with only 147 crew assigned. Although the missions for these two ships are different and the technology has changed significantly, it is clear that fewer Sailors assigned means something has to give to meet the operational availability needs of the Fleet Commanders. The reduced manpower is achieved partially due by better technology, but it also demands that many maintenance activities be provided by Navy Shore facilities and the industrial base. And, this means that the Navy Shore establishment...
will undoubtedly have a greater burden to provide a greater amount and variety of maintenance support, both at home and forward.

The skills required for maintaining ships has also changed dramatically. In the past, more of the maintenance required purely mechanical work skills. Nowadays, the technology is so advanced, you almost need a degree in computer science. Maintaining ships is one of many sustainability concerns. The health of the industrial base is a critical factor in building a sustainable fleet. It has been decades since ships were built in sufficient quantities to sustain the industrial base; that capacity is just not available. Highly skilled shipbuilding tradespeople have moved to other industries. It will take time to build up the industrial base and skilled workforce needed to meet the new demands.

In addition to the Navy’s needs, the ability to move the Army and Marine Corps is also challenged by the shortages in the US flagged Merchant Fleet. The Maritime Administrator, Paul “Chip” Jaenichen, recently detailed the multitude of issues regarding the US Merchant Fleet:

- Only 78 oceangoing US flagged ships
- Only 2% of US commerce moves on these ships (China requires 25% minimum)
- US Merchant Marine Academy produces only 9,000 of the 36,000 mariners needed to keep up with retirements

Logistical support is no longer a given

It is not feasible to fly everything in that is needed to support the Joint Force. From humanitarian operations following a disaster to high-end combat military operations, the majority of transportation will still need to come by sea. Careful analysis is needed to build the right mix of ships so they can fight their way into a more challenging theater and to deliver their supplies in places where there are no large functioning ports.

High-end warfare is back. The maritime environment for the fleet has become ever more complex, and the challenges to operating forward will continue to increase. The range of military operations that is facing the fleet has increased as our potential adversaries and competitors have improved in their capability. The recent missile attack on a high-speed vessel off the Yemeni coast is a clear example that even non-state actors have greater anti-access capability. Nation-states such as Russia and China have continued to increase their maritime capability that will greatly challenge the projection of US military forces forward. And, it is common knowledge that both state and non-state actors will target our logistical lines of communication.

Free and unfettered access is no longer guaranteed from the sea. In recent decades, the Navy has not been challenged at sea. We owned the oceans. Unfortunately, this is no longer the case in many regions. All of our ships will require the ability to defend themselves to a far greater extent.

Interoperability—more important than ever before

Even if we build a fleet of 350 ships and increase the size of the US flagged Merchant Fleet, it’s not enough to meet the global demand for naval support. America’s allies need to invest in improvements to their maritime capability to include their logistical capacities. The United States and her partners and allies will demand greater interoperability to address the Sea Power needs, both in conflict and in disaster response.

For decades, facilitating interoperability has been a top priority during global military training exercises. As naval technologies become more and more complex, these exercises become even more crucial. It also affects which investments our allies make in their own capacity-building decisions. Events such as RIMPAC 16 in June and HOSTAC in September bring together thousands of military personnel to these aims.

At the 25th Annual Surface Navy Association Symposium in January 2013, Secretary of the Navy the Honorable Ray Mabus talked about his priorities as the 4 P’s for the Navy, which were People, Platforms, Power, and Partnerships. These priorities will undoubtedly be understood as key, no matter who is in charge of the Navy.

We often fixate our attention and analysis on the pointed end of the spear, but the spear needs a shaft to truly be an effective weapon. The future fleet must keep sustainability, logistical support, and interoperability in mind.
The U.S. Navy is developing the latest in unmanned undersea vehicle (UUV) capability powered by proven automotive fuel cell technology.

By Joseph F. Mercurio, GM Propulsion Systems

General Motors (GM), Detroit, Michigan is assisting the U.S. Navy in the development of a fuel cell powered unmanned undersea vehicle (UUV) for near term demonstration using an automotive fuel cell system. UUVs are being developed to provide the Navy with increased force protection at sea while minimizing risk for Navy personnel. UUVs have the potential to perform a large number of critical underwater functions as outlined in the Navy’s 2004 UUV Master Plan. Research shows that a fuel cell propulsion system provides a path to missions in excess of 60 days without surfacing for air or refueling. The major enablers for extended mission duration are the high efficiency of fuel cells and the high energy density of stored hydrogen, which result in a UUV with extended endurance compared to battery-powered ones.

To meet the Navy’s goals for a long endurance UUV, GM is providing commercial-off-the-shelf automotive fuel cell systems to the Navy for integration into prototype vehicles. The Navy team members include the Naval Research Laboratory (NRL), the Office of Naval Research (ONR), Naval Surface Warfare Center Carderock Division and also on the development team is the University of Hawaii. While many types of custom fuel cell systems exist, automotive fuel cells are attractive for UUVs because of their high reliability and robustness, plus opportunity for dual use for lower cost.

**Technology Evolution**

GM has been developing fuel cells for automobiles since the mid-1960s. In 1966, GM developed and demonstrated the Electrovan, the world’s first hydrogen fuel cell automobile. It utilized technology originally developed for the Apollo Space Program. In the early 1960s GM committed to developing an emissions free automobile starting with a battery electric vehicle which quick transitioned to fuel cell technology. At that time, fuel cell propulsion systems required an entire van to package the various hardware elements. GM is now developing advanced, reliable fuel cell systems which can easily be packaged under the hood of a modern automobile and provide the same utility as conventional gasoline powertrains at nearly the same cost. Over the past 30 years, GM has employed a dedicated team of research and development engineers and scientists working in a number of full-scale laboratories experimenting with a multitude of concepts, materials, designs and control algorithms. GM’s automotive fuel cells are classified as polymer electrolyte membrane (PEM) fuel cells. PEM fuel cells create an electrochemical reaction between oxygen or air and hydrogen to produce electric power with a byproduct of heat and water vapor.

**Next-Generation Advances**

GM is currently developing a second-generation production fuel cell system. Earlier generation systems were utilized for several demonstration programs including the Sequel and Equinox fuel cell vehicles.

The evolution from Gen 0 to Gen 2 included a number of major accomplishments. Mass and volume were reduced by approximately 60 percent. The platinum catalyst was reduced from 90 to 12 grams per automotive fuel cell system. The bi-polar plates for the fuel cell were converted from a carbon composite material to steel which yielded a significant reduction in cell to cell thickness as well as overall stack size. To further reduce cost, extensive testing was conducted to reduce the number of system components by integrating multiple functions into single devices.

In 2007 and 2008 GM produced a fleet of 119 Chevrolet Equinox Fuel Cell Electric Vehicles (FCEVs) for demonstration and evaluation by more than 5,000 consumers, businesses, the military, utilities and government agencies in five major U.S. cities as well as Europe and Asia. By mid-2015, the fleet accumulated over three million miles and several vehicles accumulated over 140,000 miles. Lessons learned from this real world usage were incorporated into the fleet of vehicles and are also being incorporated into next generation fuel cell system designs. Each one of the vehicles in the fleet utilized a small computer to collect over 100 data signals ten times per second. The collected data was instrumental to achieving solid learnings and associated redesign solutions. The same data collection system is being used by the Navy for feedback purposes.

Operating a fuel cell and other systems below water creates a multitude of new challenges with operating pressure, corrosion and water intrusion. The massive quantities of data collected allowed the Navy and GM team to solve each challenge in a systematic manner and advance to the next test.

**Direct Defense Application**

Four of the military services, the Army, Navy, Marine Corps and Air Force have conducted evaluations of the Equinox fuel cell electric vehicles in Hawaii. Additional evaluation work was conducted at Fort Belvoir, West Point and Camp Pendleton. Tests were conducted to measure the ability of the vehicles to act as a mobile generator and export electric power. Three of the Equinoxes were configured to have the capability of exporting 25 kW continuous and 50 kW peak power. The exportable power was used to operate temporary installations as
well as provide emergency power during grid outages. The joint services were provided with extensive performance data to study with respect to fuel cell capability to power military vehicles and systems. Currently GM and the U.S. Army Tank Automotive Research and Development Center (TARDEC) are evaluating GM’s Chevrolet Colorado ZH2 with aggressive off-road capability. Test results will be available in mid-2017.

GM’s fuel cell systems operate similar to conventional automobile engines making them ideal for powering UUVs. PEM automotive fuel cell systems start-up in around one second and can accelerate to full power in around five seconds. Fuel cells operate at up to 65 percent efficiency, more than double that of a conventional gasoline-powered engine which is a major enabler to meeting the Navy’s goal of achieving mission durations in excess of 60 days. Operating fuel cells underwater without air-breathing capability, requires the vehicle to store both hydrogen and oxygen. The vehicle development team is currently planning and conducting demonstrations of the full mission duration having already conducted a demonstration of the fuel cell propulsion system operation underwater for 1,000 hours. Future demonstrations will include fueling as well as additional vehicle operation scenarios. The Project Driveway hydrogen fueling lessons will be transferred to the UUV program as fueling protocols, methods and systems are developed. UUV fueling will be considerably more complex than fueling of automobiles.

Powering a Power Source

Fuel cell propulsion for UUVs provides a number of benefits compared to battery propulsion. With battery propulsion, recharging typically requires an overnight time window and the vehicle batteries can become discharged if the vehicle is stored for an extended period. Fuel cell vehicles can be stored almost indefinitely without requiring refueling. Also the GM fuel cell system like most automotive units, can operate in both freezing and high temperatures with minimal loss of performance.

In addition to UUVs, GM’s fuel cell technology can power other military and non-automotive vehicles. The key enablers achieved using fuel cell propulsion include:

- Quiet operation and reduced heat signature
- Exportable electric power
- Water production from vapor exhaust
- High wheel torque at all speeds for wheeled vehicles
- Rapid refueling

Additional testing is planned in 2017 to validate fueling and operation with respect to the 60-day mission duration requirement. Use of an automotive fuel cell system has proven to be a major enabler to achieving the Navy’s goals. The automotive system has proven to be very reliable and required manageable steps to integrate into the unmanned vessel. In the near future the UUV will be tested in environments more representative of its ultimate use in ocean-going missions. GM is committed to providing advanced automotive technology to solve the military’s ever-changing mission requirements.
Unmanned aerial systems (UAS) are the latest wonder of the aviation world.

The United States military has used them for decades, and increasingly unmanned systems to perform dangerous reconnaissance and attack missions that save Soldiers’ lives.

As the technology proliferates, however, America’s adversaries could potentially use UAS to target this nation’s troops, necessitating a robust counter-UAS defense system for use anywhere American forces may be deployed.

U.S. Army Yuma Proving Ground recently proved its mettle in this important and growing test mission area by hosting a large scale exercise in conjunction with the U.S. Army Rapid Equipping Force (REF) that put counter-UAS systems under development through a series of rigorous scenarios.

Prime Test Environment

YPG’s clear, stable air and extremely dry climate along with vast institutional UAS testing knowledge makes it an attractive location to host this kind of work. Of at least equal importance to the counter-UAS mission, however, is the proving ground’s robust sensor-testing workload and ability to control a large swath of the radio frequency (RF) spectrum. YPG has more than 500 permanent radio frequencies, and several thousand temporary ones in a given month.

“The frequency authorizations alone are very difficult to do,” said Grant Ware, director of the Air Combat Directorate. “The ability to jam that we have here is very difficult to get in other places.”

Even more impressive was the fact that the complex test was planned and executed in about one month.

“When we came to YPG with the idea, we knew their team would do an excellent job helping us with this event, even with such a short timeline” said Lt. Col. Keith Matiskella, Solution Team Chief at the REF. “We wanted to do a unique test, and the YPG team rose to the challenge.”

Safety at the Fore

In addition to identifying sites suitable for the test’s unique needs, YPG personnel obtained safety approvals for every piece of equipment brought to bear in the course of the evaluation, from the UAS themselves to ancillary components like radar trackers.

Yuma Proving Ground, AZ, is testing and evaluating counter-unmanned aircraft system technologies which may soon find a place in DoD’s arsenal.

By Mark Schauer, Public Affairs, Yuma Proving Ground
The safety office is blessed by the attitude that every single one of our test officers have: they take safety to heart,” said Mary Svoboda, health physicist. “Their main goal is to run a safe, successful test. We have to pull in many subject matter experts to conduct a test this complex, and we are fortunate at YPG to have a large number of them.”

Realism in the scenarios was paramount: the test teams flying the UAS launched them from multiple points across YPG’s vast test range, actively choosing spots that a real adversary might seek on a battlefield.

A variety of UAS were used over the course of days, both fixed wing and rotor wing, against the systems under test. Some systems were capable of detecting and neutralizing targets, while others merely tracked them. In all, about 150 personnel supported the test, and all of this activity was accomplished without interfering with YPG’s busy test mission in the more than 2,000 square miles of restricted airspace above the proving ground, a feat that required careful coordination with other test missions. Well over 100 sorties were flown for this test, with the mock adversary forces changing position as necessary to make way for unrelated missions that required air space they had been using.

The test was a success, and YPG officials expect to see this vital mission increase going forward.

More info: yuma.army.mil
MAXIMIZING ENERGY RESILIENCY


Interview conducted by DoD P&E Editor Kevin Hunter

DoD P&E: From a global perspective, how is DLA Energy improving energy resiliency through enhanced operational capabilities?

Brig. Gen. Chapin: Defense Logistics Agency Energy is one of six Primary Level Field Activities at DLA. DLA Energy is the Executive Agent for all bulk petroleum. An Executive Agent is a designation by the Secretary of Defense when an agency or department is responsible for support services common to two or more Services. DLA Energy provides petroleum products, utilities, alternative fuel/renewable energy, aerospace energy, fuel quality/technical support, fuel card programs, and installation energy services. Energy is organized to work with customers and suppliers to meet the needs of the Warfighter, Department of Defense and other government agencies.

We continue to set the standard for warfighter support and productivity. DLA Energy had approximately $10 billion in sales in Fiscal Year 2016 and issued a total of 4,171,483,887 gallons of fuel in FY 2016. DLA Energy also manages 15 million MWhs of electricity valued at over $900 million under multiple year contracts and has Energy Savings Performance Contracts at multiple locations providing our customers with an estimated savings of over $300 million annually.

Our business is simple. Get the warfighter what they need and get it on time. And that means getting the fuel to warfighters everywhere.

DLA Energy is developing a resilient and redundant energy supply chain to execute a global fuel strategy. We are validating and adjusting fuel requirements across the various regions to ensure the appropriate amount of fuel is on hand. Here are a few examples.

DLA Energy participated in the European Reassurance Initiative for the U.S. European Command. This $1 billion program includes five broad lines of effort aimed at funding bilateral and NATO assurance efforts. The lines-of-effort are increased presence; additional bilateral and multilateral exercises and training; improved infrastructure; enhanced prepositioning; and building partner capacity.

In Australia, we are partnered more closely with local commercial supply chain capabilities on bulk petroleum storage, distribution and operational use. Examples of our ongoing fuel relationship include the Into-Plane contract locations in Cairns, Sydney, Brisbane and Canberra International Airports.

Improving fuel access with the Australia Defence Force will not only maximize interoperability, but significantly improve maritime security cooperation by extending operational range and reducing dependency on dislocated commercial-grade fuel supplies in the Asia Pacific. This is a game changer for both Australian and U.S. forces, from the Coral Sea all the way to the South China Sea.

DLA Energy is extending the petroleum supply chain in the CENTCOM Area of Responsibility and implementing additional capabilities in strategic locations such as in the Middle East. DLA Energy continues to expand and refine its role in managing the bulk petroleum supply chains in Afghanistan (Operation Freedom's Sentinel) and Iraq (Operation Inherent Resolve). Enhancements to commodity, fuel storage and distribution contracts have occurred as lessons-learned in this theater and are being applied throughout the supply chain.

In June 2016, Defense Fuel Support Point (DFSP) Salalah, Oman opened a contractor-owned, contractor-operated site with the capacity to receive, store, and issue both Jet Fuel (JP5) and Naval Distillate Fuel (F76). This DFSP improves our logistics capabilities outside the Arabian Gulf and enables NAVCENT to better support U.S. 5th Fleet Maritime Forces operating in the North Arabian Sea, Horn of Africa, and Gulf of Aden.

DoD P&E: In what ways is DLA Energy leveraging commercial capabilities to gain supply chain efficiencies such as velocity/impacts of Jet A conversion, and other efforts?

Brig. Gen. Chapin: In terms of scale, the Department of Defense consumed about 70 million barrels of jet fuel in 2016. Major US airlines consumed more than 386 billion barrels in the same year. We have converted CONUS JP-8 requirements to commercial JET-A with additives. This has vastly increased the supply base while reducing costs to the war fighter. In OCONUS areas, conversion to commercial Jet-A1 with additives is nearly complete. Since DoD only consumes about 7-9 percent of the commercial jet fuel in the US, that means there are vast quantities of fuel available around the country which DoD could tap into instead of relying on a specific military product. Integrating more Jet A1 increases the velocity and resiliency of our supply chain, expands our supplier base, and reduces our need for infrastructure. It is a faster, better, cheaper solution for the warfighter to leverage pre-existing worldwide logistics infrastructure and processes.

Building on successful conversions in Europe, the Mideast, CONUS, and parts of the Pacific, the conditions are now set to expand this initiative to the Japan area of operations. DLA-Energy is working to transition
the supply network in Japan from the current practice of adding jet fuel at the refinery in Korea, to injecting nearer to the customer. This change will enable any jet fuel provider in the Pacific to become a source of supply for the war fighter in Japan. This effort will also leverage the Japan Air Self-Defense Force’s conversion to Jet A1, providing opportunities for expanded mutual support.

DoD P&E: As DLA works to enhance supply diversity in commercial and alternative fuels, renewable energies such as PPAs/ESPC, and other areas, how is small business benefiting in the short/long term?

Brig. Gen. Chapin: Competition is a great incentive. We seek to bring on as many vendors as possible, increasing our portfolio of industry partners in the energy marketplace. That includes small businesses. We have an OSD mandate to increase our utilization of small business.

DLA Energy measured the value of DLA awards to Small Business, Small Disadvantaged Business, Women-Owned Small Business, Service Disabled Veteran-Owned Small Business and Historically Underutilized Business Zone Small Business against DLA established targets. DLA Energy current performance of 22.1 percent exceeded our DLA-assigned goal of 21.29 percent for FY16. The last four years (including FY 16) DLA Energy has met or exceeded its goal.

DoD P&E: From an evolving business processes perspective such as EBS, audit readiness, communications with industry and solid core such as direct delivery fuels, natural gas, electricity, utility services, bulk services, and aerospace, speak to DLA efforts to push partnering efforts in maximizing capabilities development.

Brig. Gen. Chapin: When we talk about the Energy supply chain, there is an effort to transition from procuring military specification fuel and leverage additional commercial product when possible. That increases the resiliency and efficiency of our supply chain when we capture the existing industry capacity.

Strong relationships with external partners are critical. We are focused on developing innovative business relationships with our industry, DoD partners and our foreign allies. We want to leverage what is out there in the commercial industry: emerging technologies, application of state-of-the-market tools for supply chain management, innovative solutions, and existing infrastructure.

We seek to build a competitive infrastructure. DLA’s Enterprise Business System was the first and arguably most successful Enterprise Resource Planning system in the Defense Department. EBS is the architecture, that system of systems, enables our supply chain planning and execution.

In fiscal year 2016, DLA Energy executed 359,291 Contract Actions valued at $6.3 billion. These transactions included Bulk Fuels, Bulk Services, Aerospace Energy, Utility Services, Direct Delivery Fuels, and Internal Support.

The Sustainment, Restoration and Modernization team in conjunction with the Service Control Points and Construction Agents have conducted multiple Continuous Process Improvement Events over the past two years. These events have resulted in improved project approval times as well as an increase in tank repair velocity. We continue to enhance operational metrics and synchronize our repair activities across all Service and Construction Agents. The SRM Program is able to fund every validated Service requirement and was able to award over $600M in maintenance and repair contracts through the Construction Agents in FY16.

DLA Energy supports DoD’s installation energy strategy to reduce energy costs and improve the energy resilience of our fixed installations through its competitive natural gas and electricity purchase programs, its execution of energy savings performance contracts, and its negotiation and award of large-scale, on and off-site renewable energy generation contracts for the Services. DLA Energy’s execution and administration of contracts in these areas helps to improve energy performance at DoD installations, lower energy and water costs, reduce the Department’s reliance on fossil fuels, and improve the energy resilience of our military bases.

DoD P&E: Is there anything else you would like people to know about DLA Energy?

Brig. Gen. Chapin: I am proud to announce that Defense Logistics Agency Energy is bringing back the Worldwide Energy Conference after a seven-year hiatus. It will be held at the Gaylord National Hotel and Convention Center, National Harbor, Maryland on April 10-12, 2017. The 2017 theme is “Refining Global Energy Strategies.”

The 2017 DLA Energy Worldwide Energy Conference is an excellent opportunity to learn about the latest trends and technologies in the energy industry. The conference promises to reach new heights in featuring distinguished government and industry speakers addressing a multitude of energy issues.

The Deputy Assistant Secretary of Defense for Operational Energy has been invited to be one of our noted speakers.

For more information and to register, www.wwenergyconference.com
When people think of unmanned systems, they tend to focus solely on the aircraft. However, what many do not realize is that these unmanned aircraft systems (UAS) are monitored and controlled by a different hero in the unmanned systems universe – the ground control station. Today, this technology can control multiple unmanned systems, from multiple domains, and from thousands of miles away. However, this was not always the case. As UAS technology evolved since its inception in the early 1980s, the associated command and control systems have evolved along with it – allowing command and control systems to maintain their place as the hero within the unmanned systems world.

The Hub

An unmanned aerial vehicle’s (UAV) command and control technology lies within its ground control station. This station acts as the hub for the system. While there are auto-pilot features that are critical to flight, the core of the mission is planned, executed and controlled from the ground control station. After the data is collected from the UAV’s sensors, the aircraft then streams the data to the ground control station or remote user, where it can then be processed into information locally or disseminated to other users in near real time.

This networking hub (the ground control station) consists of both hardware and software components. The brains of the ground control station (the control software and operating system) are housed in the processing unit. There are also various levels of software applications that are integrated with the core aviation software.

The Chaos of Early Ground Control Stations

Many of the first ground control stations took form in the 1980s – when UAVs were starting to emerge as capable enough for operational use. At this time, these systems were designed to operate just one type of aircraft – with only one domain in mind. However, this design remained aligned with early mission requirements – which at the time, started as primarily electro-optical/infrared (EO/IR) intelligence, surveillance and reconnaissance (ISR) missions.

Due to the state of the technology, these stations were made up of a collection of separate systems, broken up by functions, instead of operating together as an integrated capability. Vehicle control, payload control, voice communications, chat communications and situational awareness information are just some of the functions that required different screens, keyboards or headsets, and were not integrated with each other. This required the user to switch between different hardware and software interfaces to carry out the mission – a very demanding operation for operators to navigate.

When it came to the human factors, these systems did not focus on comfort and ease-of-use. For example, since the systems were made up of separate parts and functions, the operator managed all coordination between the systems. This usually involved physically switching between components, reaching for controls or listening to multiple headsets at once. Unfortunately, these operators would sit in these systems for hours, causing an uncomfortable working environment. This was because adding capability and features was more important at the time than understanding the human-machine-interface.

However, the pioneers of these early systems and the lessons learned from their innovations and operational experiences were critical to the infancy of the technology.

The Evolution Catalysts

Throughout the next couple decades, as tension increased within several regions around the world, UAS became increasingly more prevalent – causing a significant surge in demand for UAS systems and with them their ground control stations.

As this demand increased and more systems populated the battle space, the mission requirements became more complex and intertwined. To keep up with these more complex mission requirements, new UAV sensors were created, providing the operator with new information that they had not seen or analyzed before. New aviation force structures were also created to extend the reach of manned systems. For example, with the emergence of
TECH SPOTLIGHT

INNOVATION CONTINUES ON GROUND CONTROL SYSTEMS

It's been approximately 30 years since the Ground Control Station 2000 began controlling the Pioneer UAS. Since then, Textron Systems' control systems have grown through various configurations and enhancements to become what it is today. As with the industry's early ground control stations, Textron Systems' command and control platform started with basic hardware and software technology – and have matured alongside its aircraft systems in order to meet the ever demanding customer missions.

"We had a vision for the next-generation of unmanned command and control – and we are making this vision a reality with our new family of command and control products – Synturian™," said Textron Systems Unmanned Systems Vice President of Control and Surface Systems Wayne Prender. "We believe Synturian provides solutions to many of the common command and control requests from the unmanned community."

Synturian features the capability to switch between platforms easily and quickly. This will provide significant cost savings for operators who use both of Textron Systems' UAS, the Aerosonde™ Small Unmanned Aircraft System and the Shadow TUAS, as well as other non-Textron Systems platforms. By including a ground control station for multiple platforms on one hardware system, this provides cost savings for UAS trainers who have to train students on many platforms.

Additionally, Synturian has been developed to optimize the system's size and weight – striving to get the system increasingly smaller, until it is eventually the size of a laptop while remaining fully functional.

"The Synturian family of products was designed around a service-oriented architecture for rapid integration of off-the-shelf software," says Prender. "The intuitive interface, which has already been tested on multiple flights, allows for streamlined training and operations. With these developments, we believe Synturian is a game-changer in the marketplace."

Textron Systems launched the Synturian family of command and control products in October 2016. The company is continuing to develop its technology to remain current with the ever-advancing UAV technology.

manned-unmanned teaming (MUMT), where UAVs extend the situational awareness of manned aviation assets, there is a need for command and control to be pushed to multiple end-users for mission collaboration. UAS manufacturers were also seeing requests for flying within more complex environments, where airspace isn't necessarily restricted all the time. These emerging factors caused a need for ground control stations to evolve to maintain their place as the hero of the UAS universe.

Today's Ground Control Stations

To successfully accomplish these new missions, ground control stations became more advanced, while also becoming more integrated and easier-to-use. We, as an industry, have recognized that the reliability and effectiveness of these unmanned systems lies very much in the human-machine interface.

Today's systems are now able to control multiple platforms within the same domain – a benefit for customers who own several various aircraft systems and operators who control various UAVs throughout their time in the field. For example, Textron Systems' Universal Ground Control Station (UCGS) can control the Shadow TUAS, as well as the Hunter and Gray Eagle® platforms.

One of the largest differences between early ground control stations and today's, are the improvements in integration and interoperability. While the early ground control stations consisted of multiple separate parts, today's systems are more integrated, as their separate parts work together as one. This provides increased reliability and maintainability, which are important factors in successfully completing a mission.

These systems are also designed with the operator and missions in mind. For example, today's ground control stations are customizable and mobile. Operators can choose how they want to interact with the system – and even customize to the point where they could choose between a mouse, keyboard, hand controller or touch screen to operate the system. Additionally, today's systems are small enough and mobile enough to provide location flexibility. For example, the ground control station could be housed anywhere from an emplaced operations center, to the back of a mobile humvee (HMMWV). Command and control has even moved to remote products, where some of the capability you would see in a ground control station is accessible on a mobile phone or tablet – providing C2 to the tactical edge.

What's Next for The Future of the Unmanned Systems Hero

Although today's systems are a significant improvement from where we were in the 1980s, there is still work to be done to remain ahead of advancing unmanned systems technology.

With relation to hardware, we believe miniaturization and open architecture will be prominent trends. The components within the ground control station are continuing to shrink – making it possible for the customer and operator to bring their mission to wherever they need it. Meanwhile, an open architecture, where interfaces would allow for third party software or hardware integration, would increase the ability for information to be shared. This allows for additional capabilities to be added, even if the original equipment manufacturer does not develop it, which opens the door for commercial standards into legacy government and military systems.

Due to the number of advancements made to command and control technology since their inception in the 1980s, today's UAS can accomplish missions within a wide range of applications – including infrastructure inspections, border security, and monitoring of assets like oil or infrastructure. Going forward, as these missions become more complex and widespread, we expect ground control technology to continue to evolve and become more advanced, which will help them maintain their place as a hero of unmanned systems.
The first LCS deployment, from February to April 2010, featured the Surface Warfare Mission Package (SUW MP) configuration. USS Freedom (LCS 1) deployed with two Gun Mission Models (GMMs), Mission Package Application Software (MPAS) hosted on the ship’s Mission Package Computing Environment (MPCE), a MH-60S helicopter, the Maritime Security Module (MSM), support containers, and Sailors. LCS 1 operated within the U.S. 4th Fleet (C4F) in the U.S. Southern Command (USSOUTHCOM) Area of Responsibility (AOR). The SUW MP proved to be extremely successful throughout the deployment. During its 47 days operating in the region, USS Freedom conducted counter trafficking patrols in the Caribbean Sea and off the coasts of Central and South America, in support of Joint Interagency Task Force-South, USSOUTHCOM and the U.S. Coast Guard, with the SUW MP GMM fully operational.

From March to December 2013, USS Freedom was deployed to Singapore with a SUW MP embarked. LCS 1 worked with many regional navies that operate comparably-sized ships during a series of port visits, exercises and exchanges. This deployment demonstrated the LCS forward deployment concept and reinforced ongoing cooperative security efforts with the U.S. Navy’s partners and allies throughout Southeast Asia.

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The SUW MP attained Initial Operational Capability (IOC) in November 2014 following successful completion of Initial Operational Test & Evaluation (IOT&E). At the same time, USS Fort Worth (LCS 3) began a 16-month rotational deployment to Singapore with a SUW MP embarked. This deployment implemented lessons learned from USS Freedom’s 10-month deployment and included additional port visits and exercises with regional navies. The SSMM is currently undergoing developmental testing with operational testing scheduled for March 2017. The Navy plans to have the system fielded to the fleet by December 2017.

The Navy commissioned its newest Freedom-variant littoral combat ship, Detroit (LCS 7), Oct. 22 on Detroit’s waterfront. Detroit is the sixth U.S. ship in our nation’s history to be named in honor of city of Detroit. The Lockheed Martin-led industry team is currently in full-rate production of the Freedom-variant, with six ships under construction at Fincantieri Marinette Marine (FMM) and three more in long-lead material procurement.

Looking Ahead

USS Gabrielle Giffords (LCS 10) will be the next LCS to be delivered to the U.S. Navy. Following its commissioning in Galveston, TX, slated for 2017, LCS 10 will sail to California to be homeported in San Diego with sister ships USS Independence (LCS 2), USS Coronado (LCS 4), USS Jackson (LCS 6) and USS Montgomery (LCS 8).

Several more Independence variants are under construction at Austal USA in Mobile, AL. The future Omaha (LCS 12) and Manchester (LCS 14) are preparing for Builders Trials in 2017. Tulsa (LCS 16) is scheduled to be christened in early 2017. Other sister ships, Charleston (LCS 18), Cincinnati (LCS 20), Kansas City (LCS 22), Oakland (LCS 24) and Mobile (LCS 26) are all in varying stages of construction.
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