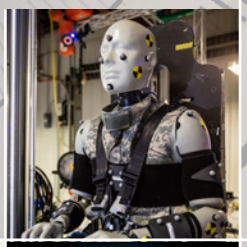
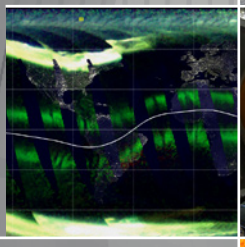
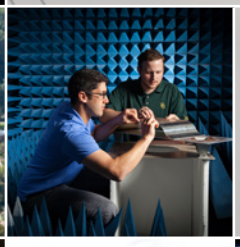
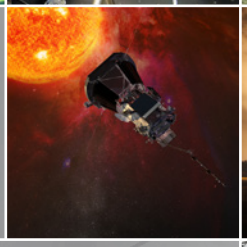
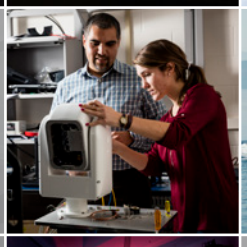
2015 ANNUAL REPORT

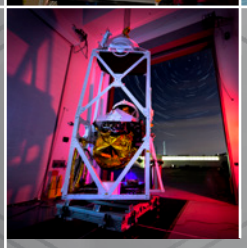








APL JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

About The Johns Hopkins University Applied Physics Laboratory

The Johns Hopkins University Applied Physics Laboratory is a university affiliated research center that develops solutions to critical national challenges through the innovative application of science and technology. Our scientists, engineers, and analysts serve as trusted advisors to government, developing capabilities and ensuring the reliability of complex technology programs that strengthen the security of our nation and advance the frontiers of science and space exploration.

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July 13, 2015: The historic, first close-up image of Pluto taken by the APL-built New Horizons spacecraft. (NASA/JHUAPL/SwRI)

Director’s Message

On the night of July 14, I had the honor and privilege of introducing the New Horizons mission team to a worldwide audience just minutes after confirmation that the spacecraft they operated—and that APL designed and built—had completed the first reconnaissance of Pluto.

I was, and still am, awed by this accomplishment. Scientists and engineers had long wrestled with the daunting challenges posed by a Pluto mission, and it was a determined team of APL and our partners that combined the right amounts of imagination, persistence, and affordable and advanced technology to make the mission happen, and then to make history on the outer frontiers of our solar system.

That is exactly the kind of challenge and opportunity we embrace at the Johns Hopkins University Applied Physics Laboratory. For more than 74 years, APL has dedicated itself to developing technologies that safeguard our national security and increase our understanding of the universe. Over the past seven decades, we captured the first photograph of Earth from space, developed the first satellite navigation system, and provided our nation’s military forces with capabilities that gave them needed and decisive technological advantages.

Today, the threats to our nation’s security have never been more complex. We face the global proliferation of advanced weapons and cyber technologies, rising nationalism and radicalism, and the burgeoning costs of maintaining our nation’s weapons systems while developing next-generation capabilities.

APL scientists and engineers confront these and many other challenges with urgency and creativity. During the past year, we collaboratively applied our technical expertise and domain knowledge to develop low-cost, innovative solutions and prototypes to solve our sponsors’ most complex problems in areas that range from air and missile defense, undersea systems, and cyber operations to space science and technology and national health.

New Horizons made international headlines, and the attention paid to this historic endeavor was richly deserved by the amazing scientists, engineers, and many other people and organizations responsible for the mission’s success. Equally impressive were the essential contributions of other APL scientists, engineers, and staff members who worked tirelessly to advance the frontiers of science and protect the security of our nation and its citizens.

As we enter our 75th year of service to the nation, we remain steadfastly committed to our role as a trusted national resource focused on creating defining innovations that will ensure the preeminence of our nation in the 21st century. We look forward to the coming year with enthusiasm and welcome the opportunities to continue to make critical contributions to critical national challenges.

Air and Missile Defense

APL scientists and engineers, with over a decade of successful research into laser-based communications, have developed an ambitious and successful terrestrial free-space optics communication demonstration program.

Developing and Applying Laser-Based Communication Technology for Air and Missile Defense

For more than 40 years, scientists and engineers have sought to develop free-space optics (FSO) or laser-based communication technologies as an alternative to conventional radio frequency (RF) and microwave communications. The advantages of this theoretical region of the electromagnetic spectrum are potentially game-changing, offering long-range, high-capacity data-transmission rates, free from complex RF spectrum planning and highly resistant to detection and interception when traditional communication systems are degraded or denied.

Historically, intelligence, surveillance, and reconnaissance applications have driven the need and requirements for laser communication links because these applications require high volumes of sensitive data to be transmitted over great distances from sensors to receiving stations. More recently, interest has also grown in the use of laser-based communications for air and missile defense systems to deal with increasingly sophisticated electronic countermeasures and an overcrowded RF spectrum.

During the past decade, the technical maturity of systems components for the commercial optical fiber communication field has substantially aided these efforts. APL scientists and engineers, with over a decade of successful research into this technology, have applied their previous successful innovations in FSO and developed an ambitious and successful terrestrial FSO communication demonstration program to improve security and capability across a range of national security applications.

Initial Research Efforts

APL work in this area began with an internally funded field test in 2005. During the test, a laser communication link was established between a ground vehicle and an aerostat. APL designed and built the optical modems used in this test to provide the interface between the test equipment and the laser communication terminals.

A number of novel concepts were demonstrated during the test. First, the link between the aerostat and a ground station provided a foundation for laser-based communications with unmanned aerial vehicles. A second and equally significant takeaway was the field testing of wavelength division multiplexing, similar to the use of multiple concurrent wavelengths, each with a unique data stream, used in modern fiber optic communications systems. This approach was heavily leveraged during this test, with as many as six unique multi-gigabit-per-second communication channels operating within the laser communication link.

Although this experiment focused on data rates and tracking of a moving airborne target, it also provided valuable insights regarding the variance in optical power between the transmitter and receiver over very short time periods. The surges and fades in signal transmission and reception caused high bit-error rates that would need to be addressed and overcome to develop a robust laser communication data link.

Later, in a 2006 demonstration, APL and its research partner, AOptix Technologies, established a 147-kilometer laser communication link between Maui and the Big Island in Hawaii. This test was a significant step forward in terms of range, and it further reinforced the need to deal with variability in the received power from the optical link before detection of the signal.

Using lessons learned, APL developed an optical automatic gain control system to dynamically normalize the received optical power from a fading channel. APL has also been continuously developing new optical modem technologies designed to decrease the amount of optical power required at the receiver to produce an error-free link.

Since 2007, these efforts have been joined and accelerated through a series of experiments conducted in partnership with the Air Force Research Laboratory and the Defense Advanced Research Projects Agency (DARPA). Although laser communications offer the same data capacity as fiber optics and are highly resistant to detection and interference, the signals can be blocked by clouds, requiring backup means in the form of automatic optical path rerouting and use of wideband millimeter-wavelength RF that can penetrate clouds. Through efforts funded by these research partners, progress in this area has been significantly expanded and extended, resulting in hybrid laser–RF communication network applications. Using a combination of hybrid laser–RF links, APL and its research partners AOptix and L-3 Communications developed a robust optical modem architecture and packet retransmission methods, providing an all-weather, high-volume, and low-detection communication capability.

Following a successful DARPA-sponsored and APL-led multinode hybrid laser–RF network demonstration in 2012, APL determined that significant size and weight reductions in the enabling technology were necessary before tactical implementation and began an internal size, weight, and power (SWaP) reduction effort targeting smaller platforms better suited for communications relay missions. This SWaP reduction and continued technology development effort, still ongoing, leverages commercial, inexpensive stabilized gimbals and has resulted in an 80- to 90-percent reduction to date in size, system weight, and power.

Looking Ahead

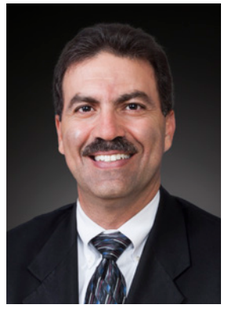
APL's long-term commitment to this technology has resulted in significant demonstrations of capability, such as a stable laser communication link with an airborne platform, the longest known terrestrial laser communication links, and the first hybrid laser–RF network. The multiple performance gains of laser communications systems open up various potential applications, including long-range, multi-gigabit-per-second data transfer and operation in RF-denied environments.

APL plans to complete a two-node, reduced SWaP, tactical demonstration FSO system. This APL-funded system provides a research platform to showcase advances in the state of the art in FSO communications, and it is intended to be usable in tactical environments to demonstrate the game-changing potential that laser communications systems bring to national defense. Future research efforts will be focused on integrating the APL FSO system with a millimeter-wave backup to provide autonomous and continuous operations across a variety of communications environments.

Working with the Navy and Missile Defense Agency, APL played a key role in the first intercept flight test of the Aegis Ashore system at the Pacific Missile Range Facility. (Missile Defense Agency)

Air and Missile Defense

Since 1942, APL has created advanced technologies and prototypes of capabilities to help protect U.S. and allied naval fleets and forward-deployed forces from air attack. Today, we continue to perform this vital mission in an increasingly dynamic and complex environment, as we evolve to address new and emerging threats posed by advanced long-range ballistic and cruise missiles. We devise, develop, engineer, test, and evaluate solutions that address current and future air and missile defense needs. We apply our expertise to make current systems more effective, and we have adapted several technologies for new missions and developed novel technologies for future implementation.



Mike White
Mission Area Executive

Aegis Ashore Success

APL co-led the initial study that was instrumental in the government decision to develop Aegis Ashore. APL also played a key role in the first intercept test of the Aegis Ashore system, which used the Standard Missile-3 (SM-3) Block IB missile to destroy an incoming target at the Pacific Missile Range Facility in Hawaii. Flight Test Operational-02 Event 1a was set up to assess the operational effectiveness of Aegis Ashore as part of the Ballistic Missile Defense System (BMDS) Phased

Adaptive Approach Phase 2 architecture. APL experts worked closely with the Missile Defense Agency and industry partners to plan the complex test scenario and analyze system performance. A BMDS radar tracked the target during the test and then relayed target track information to the Command, Control, Battle Management, and Communications system for transmission to the Aegis Ashore test system. On the basis of that data, Aegis Ashore calculated an intercept solution, fired the SM-3, and guided it to a lethal intercept of the target. The successful operational test is a critical milestone for Aegis Ashore, planned to begin operations in Romania in 2016.

Naval Integrated Fire Control – Counter Air (NIFC-CA)

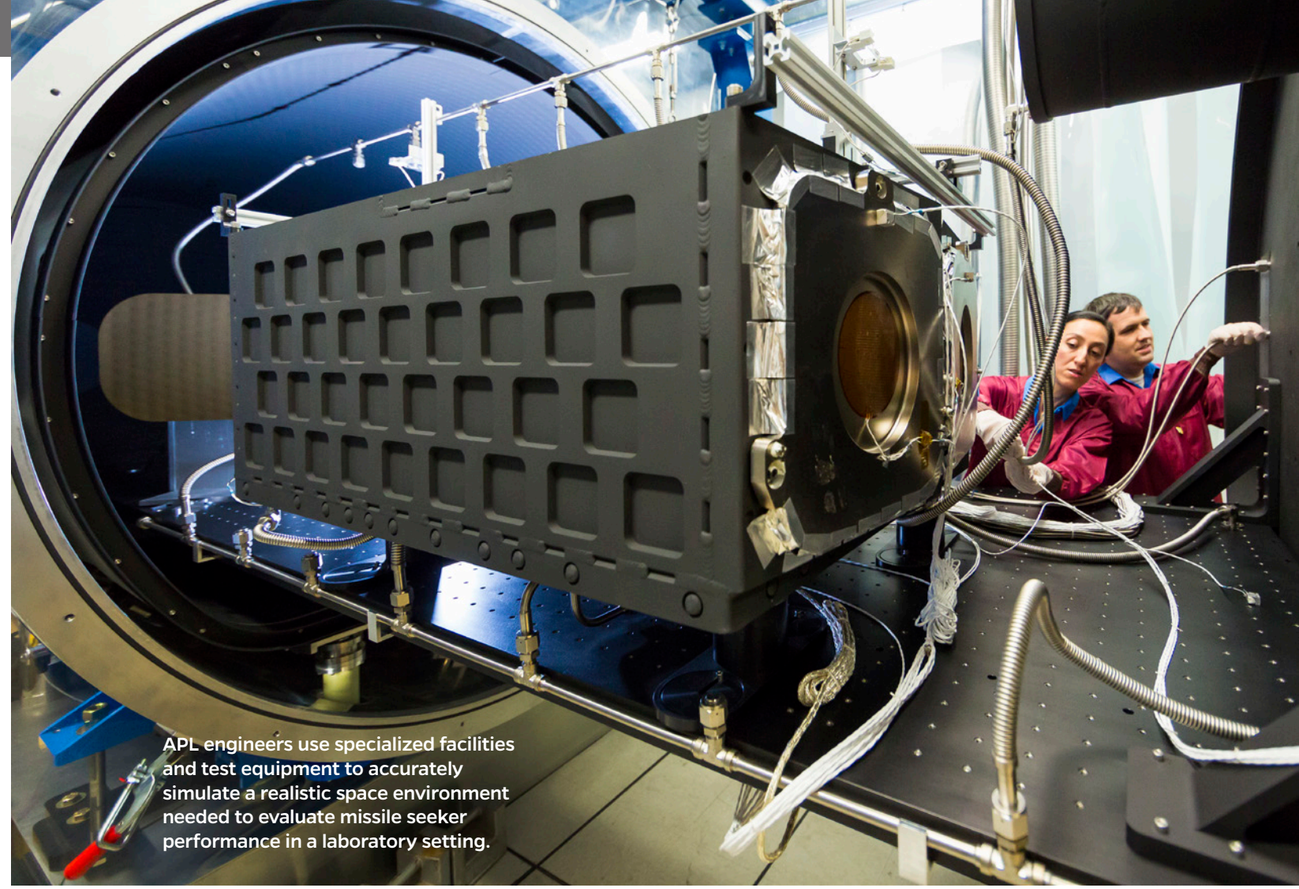
NIFC-CA is a system of systems working together to coordinate fire control and provide engagement opportunities beyond the horizon—a key to U.S. military strategy. Over the past few years, APL and its military partners have expanded the battlespace greatly, allowing a shooting ship to get a coordinated picture and engage a variety of targets at much greater range. APL provided thought leadership for improvements to NIFC-CA called Increment 2 and helped accomplish a successful test by holding major milestone meetings and weekly teleconferences to streamline communications both within and outside the Laboratory. APL subject-matter experts participated in at-sea work-up exercises with the first NIFC-CA-capable Carrier Strike Group just prior to initial fielding in March 2015. APL will continue to work with its partners to provide leadership for future NIFC-CA increments as they are designed, tested, and transitioned to the fleet.

Ship Self-Defense System Fleet Briefings

Throughout 2015, APL provided a pivotal role in preparing U.S. Navy aircraft carrier and amphibious warfighters with the latest information about the Ship Self-Defense System (SSDS) Integrated Combat System (ICS) prior to deployment. APL developed SSDS ICS anti-air warfare capabilities and limitations briefings aboard several SSDS ships. These briefings were delivered to ship commanding officers, executive officers, combat system officers, tactical action officers, and watch standers, in addition to carrier strike group and expeditionary strike group staff, prior to deployment. The briefings facilitated valuable discussions between the warfighters and APL's subject-matter experts regarding adversary cruise missile capabilities and the ship's ability to defend itself against those missiles. These interchanges enhanced warfighter readiness and promoted awareness of SSDS capabilities and limitations prior to deployments throughout the world.

First Flight of Advanced SM-3 Block IIA Missile

Working with the Missile Defense Agency (MDA) and industry partners, APL played a key role in the successful completion of the first live-fire test of a Standard Missile-3 (SM-3) Block IIA guided missile. During the test—called SM-3 Block IIA Cooperative Development Controlled Test Vehicle-01 and conducted at Point Mugu Sea Range in California—the missile successfully operated through all three propulsion stages to achieve exoatmospheric flight and deployed its nose cone. APL's engineers and analysts worked closely with MDA and Raytheon Missile Systems to plan the complex test and predict system performance. The successful flight test demonstrated key performance elements of the SM-3 Block IIA system and provided valuable data to anchor APL's detailed engineering models and simulations of the missile.



APL engineers use specialized facilities and test equipment to accurately simulate a realistic space environment needed to evaluate missile seeker performance in a laboratory setting.

Multi-Mission Warfare Sea-Based Terminal Intercept Tests

APL played a lead role in the Multi-Mission Warfare Flight Test Campaign to achieve the first sea-based terminal intercept using the Navy's Aegis Baseline 9 Combat System with the Standard Missile-6 (SM-6) missile, defending against a ballistic missile target in its terminal phase of flight. The Sea-Based Terminal Ballistic Missile Defense Increment 1 capability is being developed to defend sea- and land-based forces from ballistic missile attack. In cooperation with the Missile Defense Agency, Program Executive Office Integrated Warfare Systems, and industry partners, APL conducted detailed scenario planning, led preflight performance predictions, and performed post-test data analysis for a campaign of four events demonstrating successful intercepts of short-range ballistic missile targets utilizing SM-6 and SM-2 Block IV missiles and cruise missile targets utilizing an SM-6 missile at the Pacific Missile Range Facility, Hawaii.

Asymmetric Operations

Combining its experience in combat systems and cyber operations research, APL is helping the Navy understand and address the cybersecurity of the critical combat and control systems on its tactical platforms.

Navy Cyber Awakening

APL has a tradition of identifying and solving its sponsors' most critical challenges. This tradition led APL to develop expertise in one of the most demanding aspects of modern technology: cybersecurity. During the past six years, this expertise enabled APL to help the Navy understand and address the cybersecurity of the critical combat and control systems on its tactical platforms.

In 2010, the Chief of Naval Operations recognized the need for an operational commander to take charge of cyber within the U.S. Navy. Just as the historic 10th Fleet enabled the prosecution of the enemy submarine threat during World War II and ensured access to the shipping lanes of the Atlantic, the Navy's Fleet Cyber Command (FCC) and the modern 10th Fleet were established to enable the prosecution of threats in cyberspace and to ensure access in a rapidly evolving cyber environment. Following the successful model of the historic 10th Fleet, today's 10th Fleet and FCC orchestrate naval operations in the cyber domain to establish and maintain an operational advantage for the Navy and the nation.

U.S. Pacific Command's Terminal Fury exercise in 2010 marked the first inclusion of a Joint Cyber Operations Task Force, which was led by Commander, FCC. At FCC's request, APL sent a team of experienced cyber experts to observe, assess, and provide follow-on recommendations. As Terminal Fury 10 unfolded, one thing became very clear: the combat systems that APL helped design and deploy to create an operational advantage were vulnerable to cyberattack, creating risk that was not understood or even conceived during system development.

Following Terminal Fury, the commander of FCC requested that the Laboratory host a series of technology exchange meetings to bring together the major systems commands (SYSCOMs) from across the Navy to discuss cybersecurity in the context of their programs.

These meetings identified areas of concern within Navy tactical systems. This growing concern, when coupled with parallel efforts to highlight the fleet's cyber vulnerabilities, resulted in a fortuitous opportunity to apply APL's expanding cybersecurity expertise to a proposed "live demonstration." For the first time, a highly realistic cyber experiment was conducted on board a commissioned Navy ship, during which APL's cyber expertise and prototype technologies were fully leveraged to contribute materially to this groundbreaking experiment. The experiment proved the Navy's concerns were well-founded and subsequently led to a series of actions culminating in the creation of the Navy's Task Force Cyber Awakening (TFCA) in 2014.

APL's long history with Navy combat systems, coupled with a decade of research and experience in cyber operations, positioned it ideally to support TFCA by pulling together disparate efforts from across platform and system sponsors in a quest to gain a holistic view of cyber risk across the Navy. TFCA worked to establish a CYBERSAFE program that was built on the principles of the long-standing and highly successful SUBSAFE program. CYBERSAFE will develop and apply rigorous

technical standards, certification, and auditing to a hardened, limited subset of components and processes. APL is working with its platform-based sponsors to incorporate CYBERSAFE standards into existing, developmental, and future control system designs.

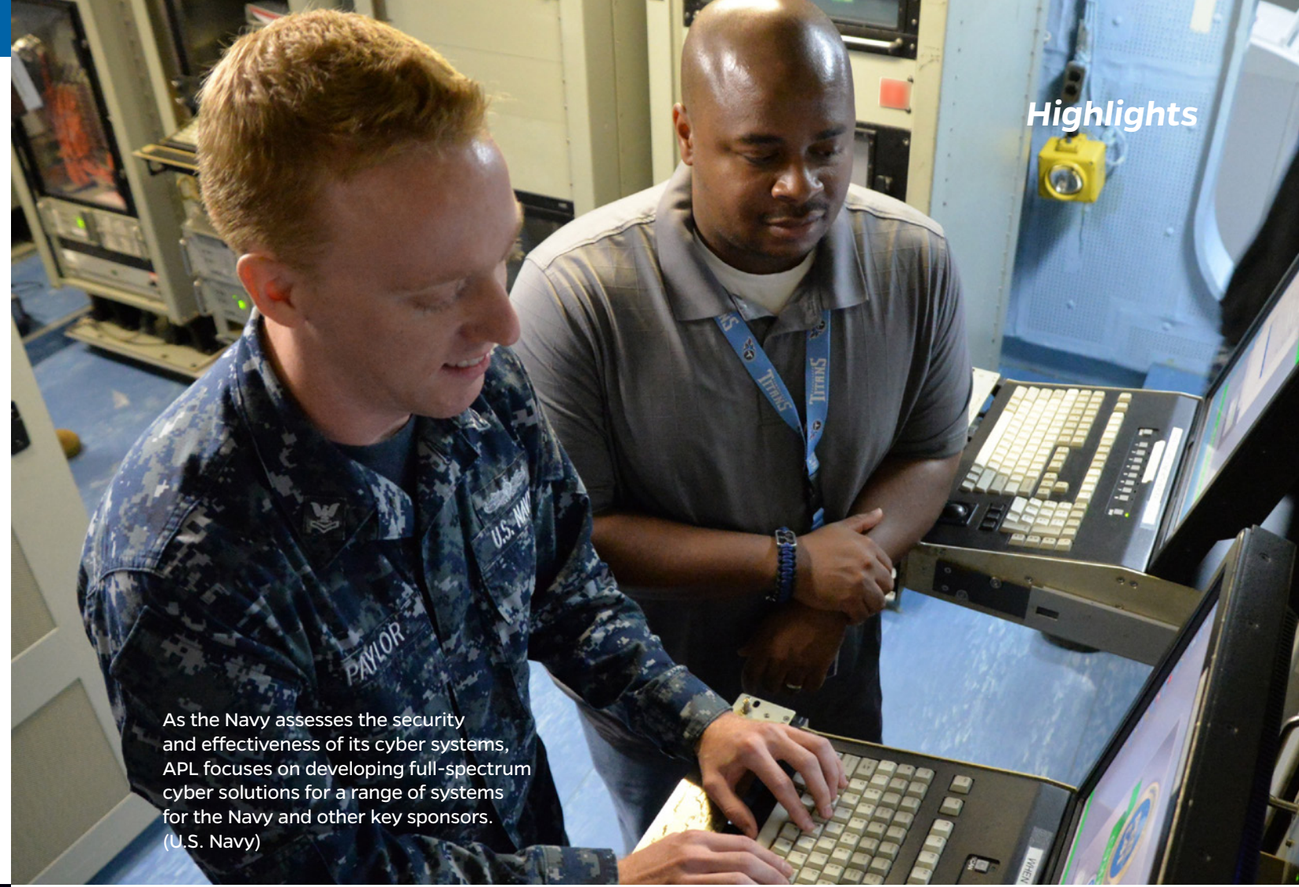
APL's efforts in cybersecurity for the Navy go well beyond TFCA and the CYBERSAFE. For example, in 2015 APL provided Naval Air Systems Command with a mission-based risk assessment of a tactical aircraft and began evaluating the secure integration of tablet technologies into the Electronic Knee Board (EKB) program. This latter evaluation led to an expanded APL task to re-architect EKB and engineer a system to meet the Navy's functional and security needs. APL also conducted research and analysis for the Naval Sea Systems Command and the Navy's Warfare Centers on cybersecurity for both surface and submarine control systems.

Today, mission areas across APL provide cyber risk assessments and cybersecurity engineering for a growing number of systems. To ensure that APL-supported cybersecurity initiatives are coordinated across Navy platforms and SYSCOMs, APL leadership established the APL Navy Cyber Forum. The forum allows representatives from across APL to expand situational awareness on cyber issues and share ideas to contribute to potential solutions. The Cyber Operations Mission Area's long-running internal research program provides innovative advances in cyber situational awareness, quantitative risk assessment, cyber defense technologies, and cyber operations tactics.

"Today, we recommission this fleet to confront a new challenge to our nation's security in cyberspace. It is a mission for which, even more so than before, victory will be predicated on intelligence and information rather than fire power."

Admiral Gary Roughead, Chief of Naval Operations
At the standup of FCC and 10th Fleet, January 29, 2010

In facilities such as the Live data, Integration, Validation, and Experimentation (LIVE) Lab, APL experts analyze cyber assets and strategies for a range of sponsors.



As the Navy assesses the security and effectiveness of its cyber systems, APL focuses on developing full-spectrum cyber solutions for a range of systems for the Navy and other key sponsors. (U.S. Navy)

Cyber Operations

We are helping to reshape intelligence and warfare around a new paradigm. APL's work broadens cyber efforts beyond point solutions, focusing on developing full-spectrum cyber solutions for key sponsor systems. Drawing from our disciplined systems engineering expertise, we are developing an agile cyber systems engineering methodology for continually changing systems as well as vigorously pursuing the science and technology needed for tomorrow's intelligence and cyber warfare systems.

Ray Yuan
Mission Area Executive

Remote Monitoring and Control Equipment

Six years ago, the program manager for Defense Communications and Army Transmission Systems tasked APL to develop and field the Remote Monitoring and Control Equipment (RMCE) system, which provides a private, secure, wide area network infrastructure connecting fully staffed Wideband SATCOM Operations Centers (WSOCs) with new, unstaffed remote sites. In 2015, APL fielded the second phase of the RMCE system, which provides remote management and control from the WSOCs in Japan, Germany, Maryland, and Hawaii to remote locations in Australia, Kuwait, Italy, Virginia, and California. This phase includes new capabilities, such as the ability for all

WSOCs to communicate with individual systems and subsystems operating at any RMCE site; an automated mechanism preventing a WSOC from unilaterally seizing an RMCE command/telemetry modem unless the WSOC currently using it agrees to a release; a view, for managers, into the internal operation and status of the RMCE network and equipment; and, where practical, remote management functionality through a cohesive, well-integrated user interface.

Cyber Electronic Warfare Studies

Before Defense Secretary Ash Carter unveiled the Department of Defense's (DoD's) second cyber strategy to guide the development of DoD's cyber forces, an APL team was tasked to conduct two cyber electronic warfare studies for the assistant secretary of defense for research and engineering. APL teamed with MIT Lincoln Laboratory and MITRE on the studies to assess emerging science and technology needs of integrated cyber electronic warfare defense and full-spectrum operations in the Pacific Command theater.

The studies helped to identify key DoD science and technology needs and gaps and the impacts to ongoing and new acquisition programs. In one study, the team looked at each step an adversary would take to attack a DoD system and identified ways that a defender could disrupt, deny, or delay those actions or operations. This study was the first to consider broad defensive countermeasures to protect U.S. combat, communications, and navigation systems against an adversary capable of generating simultaneous or sequential cyber and electronic warfare effects.

Senior Leader Communications

APL holds a key role in the National Security Agency's Commercial Solutions for Classified program, designed to extend enterprise information services into mobile environments and provide secure communications for senior leaders across the federal government. As this operational community's trusted partner, APL worked with vendors to make sure the government could leverage commercial technologies in an orchestrated manner, fielding multiple operational tests and championing secure mobile strategies and architectural approaches for improved capabilities at reduced costs. APL conducted broad technical analysis, development, and coordination and collaboration activities, leveraging a wide base of senior leader sponsors, to drive standards of interconnectivity and ensure these systems were secure and effective.

Nuclear Enterprise Review

In spring 2015, APL led a Nuclear Enterprise Review directed by the Department of Defense chief information officer. This quick-turnaround, 45-day study was commissioned to determine the nuclear command, control, and communications (NC3) enterprise's operational capability, readiness, and resiliency from the strategic level down to the last tactical mile. APL subject-matter experts identified focus areas, led study teams, and drafted the report. The final report, complete with overarching themes as well as findings and recommendations, was delivered to the deputy secretary of defense and is now serving as a key enabler for improvement across the nuclear enterprise.

The Department of Defense relies on APL expertise in critical cyber areas, from secure satellite communications to studies on emerging science and technology needs of integrated cyber electronic warfare defense.

Datacasting allows disparate agencies to receive the same data at the same time, breaking down interoperability barriers and issues associated with sending video to multiple users over a large area.

Homeland Protection

Our programs address a wide range of critical tactical and systems-level challenges related to border security, multimodal transportation security, safe and resilient infrastructure, cybersecurity, risk assessment and management, situational awareness of the threat environment, global health surveillance, and all-hazard national preparedness. The solutions we deliver for our sponsors reflect our deep understanding of operational realities and our close association with frontline security, law enforcement, and emergency response personnel.

Jose Latimer
Mission Area Executive

Datacasting

During a crisis or emergency, it is critical that important information is delivered to first responders. The challenge is to find a way to deliver it accurately and across multiple agencies, often spread out across a wide geographic area. Sponsored by the Department of Homeland Security's Science and Technology Directorate, APL is testing a technology called datacasting to determine its value to the first-responder community. Datacasting is a "one-to-many" broadcast of data, including video. This platform allows disparate agencies to receive the same data at the same time, breaking down communications interoperability barriers and issues associated with sending video to multiple users over a large area. Also, because it leverages existing television station infrastructure, datacasting enhances the reliability and availability of public safety communications, especially during emergencies. For two pilot programs held in 2015 in Chicago and Houston, APL designed and executed the technical test and evaluation with independence and rigor to provide evidence-based results. In addition, APL is analyzing the data developed during these tests. The Lab is also providing support in integrating the system into existing telecommunications infrastructures and identifying additional uses of the system.

Air Cargo Screening

APL is working closely with the Department of Homeland Security (DHS) and the Transportation Security Administration (TSA) to give the United States a technological edge to defeat terrorist and other asymmetric threats targeting air cargo. With DHS, APL scientists and engineers carefully evaluate and qualify technologies, such as X-ray, explosives trace detection, and electronic metal detection, that screen air cargo items for explosives. A key part of this effort is making sure these tools can screen a variety of cargo commodities in operational environments without imposing delays on commerce. For TSA, APL assesses vendors' claimed capabilities and devices in both laboratory and field environments. APL scientists create test materials that will generate appropriate detection responses in laboratory and operational environments, facilitating controlled and covert test activities. APL also analyzes the screening technologies' performance and finds opportunities for improvement. APL researchers are working to develop next-generation technology requirements based on their understanding of chemistry and physics, the current state of the art, and dynamic threats.

PATT Down

APL worked with the Transportation Security Administration (TSA) offices of Security Capabilities and Security Operations to develop the Pat-down Accuracy Training Tool (PATT), a life-sized mannequin equipped with pressure sensors designed to help security officers better detect prohibited items during pat-downs. PATT provides objective feedback on how much pressure officers should apply and whether they are covering all necessary areas to sufficiently "clear" an alarm. Current pat-down training and testing relies solely on classroom presentations and practice sessions with feedback from trainers and mentors, and uses only subjective measures. PATT is helping TSA make the process more consistent and is alleviating some of the stress that officers and passengers describe as part of the pat-down process—and combined with improved technology, PATT can help defeat asymmetric threats to the U.S. transportation system.

Collision Avoidance System for Unmanned Aircraft

APL plays a key systems engineering role in the design and implementation of the Federal Aviation Administration's (FAA's) Airborne Collision Avoidance System for Unmanned Aircraft (ACAS Xu). Among the many obstacles restricting unmanned aircraft system (UAS) access to the National Airspace System, fulfilling the "see and avoid" requirement without a pilot on board is the most challenging. ACAS Xu meets that demand while providing improved safety, fewer unnecessary alerts, adaptability to new sensor inputs, and interoperability with current airspace users. In FY 2015, APL led an effort on behalf of FAA to rapidly prototype, validate, and flight-test ACAS Xu on a high-performance UAS in collaboration with General Atomics Aeronautical Systems, NASA, BAE Systems, and Honeywell International, Inc. This historic test cemented ACAS Xu as the accepted solution for UAS collision avoidance and kicked off a formal avionics development process that will culminate with system standards. APL continues its leadership role in the standards-development community, helping the FAA address a very tough problem on a short timeline.

APL supports the special operations community through objective technical direction, emerging technologies, and quick-response capabilities and solutions. (U.S. Navy)

Special Operations

We create and enable asymmetric capabilities for the special operations community through objective technical direction, emerging technologies, and quick-response capabilities and solutions. These include raising situational awareness through high-precision, countermeasure-resistant tailored technology for intelligence, surveillance, and reconnaissance. APL also provides increased capabilities for military information support operations and counterproliferation of weapons of mass destruction.

Donna Gregg (Acting)
Mission Area Executive

Biosurveillance Portal

APL has developed a web-based portal for monitoring, analyzing, modeling, and predicting the spread of health-related concerns across the globe. Pulling data from an unprecedented variety of sources, the tool allows people from across the U.S. government to communicate and collaborate in real time, sharing information critical to making decisions and responding quickly to emerging or potential biothreats. The portal gives users the power to research and analyze real-time data and documented information while interacting with a wide array of professionals, including public health officers, environmental officers, clinicians, physicians, and law enforcement personnel as they maintain situational awareness during local, regional, and global crises.

Cyber and Special Operations

Looking to understand the implications of cyberspace to Army Special Operations Forces, U.S. Army Special Operations Command (USASOC) and APL are conducting a capabilities-based assessment to answer a critical question: “How does the cyberspace domain enable and impact Army Special Operations?” USASOC and APL are using an analytic process to describe cyber-space-related special operations tasks, discover capability gaps, and identify solutions for closing those gaps. The results of this effort are expected to impact training, education, policy, and material solutions—all to enable Army Special Operations to master the cyber domain.

Field Power

APL has developed a unique and valuable technology called the Operational Lightweight Intelligent Thermo Electric (OLITE) power source, which reduces the weight of batteries that our ground forces carry by as much as 60–75 percent while providing all-weather operation and quick response for operational agility. OLITE taps thermoelectric technology—based on solid state heat-to-electric conversion devices—to potentially offer 100 times more power per unit area and volume than the photovoltaic panels that U.S. Special Forces, soldiers, and Marines currently use, while overcoming limitations such as cloudy days, eight-hour operation, foliage, and lack of stealth. APL researchers have dramatically improved the power output from the prototype OLITE from about 5 to 35 watts, making it attractive for many operational needs of the warfighter. The Lab successfully tested OLITE in Fort Bragg, North Carolina, in summer 2015 and showed that OLITE can safely charge a military-grade lithium-ion battery while simultaneously powering a satellite communications radio, offering a significant new capability for increased operational agility of our Special Forces.

The OLITE power source reduces battery weight by more than 60 percent while offering all-weather operation and quick response for operational agility.

Force Projection

APL's rapid prototyping and development efforts range in size, scale, and application—but they share a common aim of quickly delivering new operational capabilities to our nation's forward-deployed forces. (U.S. Navy)

Rapidly Fielding New Capabilities to Meet Operational Needs

Less than four months after the devastating attack on Pearl Harbor in 1941, which launched America into World War II, APL physicists, scientists, and engineers were enlisted in one of the war's most secretive and successful efforts to rapidly field a new operational capability.

So began the development of the radio proximity fuze, a game-changing device that altered the course of the war in the Pacific and Europe by dramatically increasing the accuracy of anti-aircraft fire. The technology has since been judged by historians as the third most important development of the war, next to radar and the atomic bomb. Along with the development of what General George Patton called the "funny little fuze" was born APL's culture and tradition of rapidly developing and delivering technologies that solve our nation's most complex technical challenges.

That long-standing tradition continues. In fact, rapid prototyping and development is among the most impactful areas of research and development in APL's Force Projection Sector. Though these efforts range in size, scale, and application, they share a common aim of rapidly delivering new operational capabilities to our nation's forward-deployed forces.

From Electronic Warfare to High-Fidelity Modeling

Continuing a tradition that began in the mid-1960s, APL pioneers efforts to maximize the operational performance of electronic warfare systems and to counter emerging threats as founding members of the Navy-Marine Corps Jamming Technique Optimization program. Working in partnership with Naval Warfare Centers and the Naval Research Laboratory, APL rapidly models, analyzes, develops, and validates radar and communications jamming techniques, tactics, procedures, and strategies to support warfighters.

As part of our long-standing support of U.S. Strategic Command (USSTRATCOM) in its stewardship of the nation's strategic capabilities, the Lab continued development of a rapid strike mission planning capability prototype. Enhancements provide better collaborative decision-making processes, supported by multiple and integrated courses of action, and deliver measures of effectiveness with confidence assessments, where applicable. This prototype capability has been recently demonstrated to both the service and acquisition communities as a tool to enable prompt strikes against time-critical targets.

The nation's electronic warfare capabilities—carried out with assets such as the EA-18G Growler aircraft—are a main focus of APL's Precision Strike work. (U.S. Navy)

Providing "Eyes in the Sky" in Afghanistan

The surge of U.S. forces in Afghanistan in 2009 required soldiers and Marines to be stationed at small forward operating bases, outside the "umbrella" of allied surveillance aircraft coverage. To better protect these forward-deployed forces, an urgent operational need was identified to develop a tethered platform that would provide persistent surveillance of areas surrounding the bases.

In response, APL used commercial off-the-shelf components to develop and deliver a system that was deployed in six months, in time to support the deploying forces. Called the Persistent Ground Surveillance System (or PGSS), this platform likely saved hundreds of American lives. To meet the operational need, APL supported the build of 60 systems while transitioning production to commercial industry. Today, APL continues to work alongside its industry colleagues to enhance the system.

Enhanced Situational Awareness for Submarines

More recently, APL has developed prototypes to support a wide range of operational needs, including technologies to maintain and enhance the capabilities of U.S. submarines, guide autonomous unmanned systems, provide predictive modeling, and conduct simulations to assess the reliability of various technologies.

To enhance situational awareness of ocean surface traffic operating near U.S. submarines, APL designed, developed, and delivered a novel technology that allows submarine operators to receive radio frequency signals of ships' automatic identification system (AIS) without exposing the boat near the surface. Using a buoyant cable antenna and low-noise amplifier, APL engineers fielded prototypes on SSN 21, SSN 688, and SSBN 726 class submarines. In doing so, they provided new tactical situational awareness capabilities to the U.S. fleet in a matter of months.

In a related development program, APL demonstrated a capability that enables the U.S. ballistic missile submarine fleet to obtain GPS-based position updates while operating at speed and depth. The module contains a roll-stabilized GPS antenna and customized electronics that transfer the GPS spectrum through the existing AN/BRR-6 towed buoy to the ballistic missile submarine, where the signals are processed to extract the GPS-based measurements. In addition, the system incorporates an optional acoustic location system that enables the submarine to determine its position to within 25 feet when performing test launches.

In yet another program, APL engineers applied their ingenuity in developing a technology to enhance the awareness of crews using environmental measurements taken aboard the submarines. The measurements play a critical role in understanding how the local undersea environment affects sonar, radar, and optical sensor performance, and they allow submariners to best employ their sensors. The prototype was an unqualified success in tests aboard Los Angeles-class attack submarines, and this effort led to further development of advanced sensors and displays for additional classes of submarines.

Rapid Development of Unmanned Systems

Unmanned systems are transforming the way U.S. forces perform missions, yet these systems are limited by high costs in performance and endurance. To overcome these hurdles, APL has embarked on an ambitious program to demonstrate low-cost capabilities that use innovative design standards, lightweight 3-D-printed components, commercial-off-the-shelf hardware, and open-source software for system modeling and simulation. Through a rapid development process, APL engineers develop customized unmanned systems to meet mission-specific needs for operational forces.

Precision Strike

We make critical contributions to the broad Defense Department sponsor community, addressing precision strike, which includes tactical aircraft, kinetic and non-kinetic weapon systems, and end-to-end capability development and demonstration. Our work spans research and development of new technologies supporting emerging capabilities, technical support to major acquisition programs, and close interactions with the warfighting users of these capabilities. Our efforts are divided into three program areas: Integrated Strike, addressing development of end-to-end capabilities from detection through engagement; Electronic Attack, addressing development of non-kinetic capabilities; and Advanced Development, aimed at experimentation and prototyping new capabilities.

David VanWie
Mission Area Executive

Hypersonic Systems

Hypersonics refers to systems that travel faster than five times the speed of sound. Promising new capabilities based on hypersonic projectiles and missiles are under development to support vehicles ranging from high-speed projectiles launched from an electromagnetic railgun, to air-launched hypersonic cruise missiles, to hypersonic boost-glide weapons with a theater-wide strike capability. In all cases, these systems are being investigated for prompt strike applications

APL is making critical systems engineering contributions to development of the P-8A Poseidon maritime patrol and surveillance aircraft. (U.S. Navy)

in anti-access/area-denial environments. In support of these applications, APL has assessed new capabilities for predicting the three-dimensional boundary-layer transition around complex vehicle shapes, investigated novel low-cost infrared and radio frequency sensors, and developed high-fidelity, six-degree-of-freedom models to allow detailed assessments of guidance, navigation, and control strategies and their performance. These technologies underpin emerging classes of precision strike capabilities that are planned for development over the next 5–10 years.

Handheld Precision Targeting Systems

APL continued its contributions toward improving the accuracy and understanding of the overall performance of inertial targeting systems. This includes the Joint Effects Targeting System under development by the Army and the Azimuth Inertial Measurement sensor for the Marine Corps. The requirements on the weight, target location error, and solution time for these portable systems make it challenging to identify and mature both hardware solutions and to develop advanced inertial processing solutions. APL has been instrumental in providing technical expertise in maturing, testing, and assessing Precision Advanced Vertical Azimuth Measurement systems based on microelectromechanical systems used in gyros and accelerometers—as well as in understanding the accuracy and limitations of azimuth solutions provided by miniature celestial compasses incorporated in these targeting systems. APL's work this past year has also focused on developing system-level models of all of the error sources that contribute to target location accuracy, which can then be used to predict a real-time statistical measure in the confidence of the solution provided by these systems.

Swarming Innovations and Improvements

APL is developing technologies that allow U.S. forces to employ low-cost unmanned aerial vehicle (UAV) swarming capabilities in complex operational environments. These developments include command and control methods, sensors/simulators, algorithms for cooperative control, and swarming effectiveness analysis tools.

The Biometrically Enhanced Command Interface (BECI) for swarms is designed to create a continuous dialog between the human and machine to mitigate human systems integration issues that arise with the introduction of complex autonomy. Because autonomous systems are capable of behaving independently of operator input, the human is often relegated to a monitoring role. BECI implements noninvasive cognitive activity sensors and multimodal input technology in an immersive virtual environment to create a persistent dialog between operator and machine.

Additionally, for a swarm to be effective in an operational environment, the individual vehicles must work cooperatively to accomplish the mission objectives. APL is using advanced autonomy and decentralized control algorithms to improve swarming effectiveness and is testing them on APL-developed quadcopters equipped with readily available commercial sensors, autopilots, and communication radios. These vehicles improve our ability to operate swarms and reveal vulnerabilities that may be exploited to defeat an adversary swarm.

Maritime Patrol Surveillance Aircraft

APL contributes to follow-on development to the P-8A Poseidon maritime patrol and surveillance aircraft in three specific areas: Advanced Airborne Sensor (AAS) radar integration, P-8A Quick Reaction Capabilities (QRC) track management and sensor control, and Systems Engineering for Increment 3 and the Maritime Patrol and Reconnaissance Family of Systems (FoS). The AAS Airworthiness Test Program uses the first test P-8A to generate data for the aircraft's special mission configuration. QRC testing begins with data collection and introduces new radar software to enable additional capabilities for the mission processor. Increment 3 is a revolutionary change to the plane's mission architecture, enabling future applications to run within the P-8A mission system and operate with multiple levels of security and vastly improved connectivity. To improve maritime and littoral domain awareness, future P-8As will have improved reach-back to the global information grid and the capability to exchange information with both manned and unmanned surveillance assets operating as a family of systems. APL is supporting efforts to integrate and manage this complex development.

Multi-Domain Analytic Framework

The increasing sophistication of adversary anti-access/area-denial (A2/AD) strategies poses new challenges to our nation's security. APL's history of complex, effective modeling and simulation capabilities for sponsors in the guided missile, electronic warfare, and surveillance domains uniquely positions the Lab to contribute to discovery of solutions. APL has determined that an innovative internal orchestration of these separate capabilities into a multi-domain analytic framework would provide the nation and APL sponsors with broad new capabilities to defeat A2/AD. By pursuing broader sets of concepts, technology evaluations, and analyses—including innovative means for defeating key difficult targets, across the entire effects chain and with heterogeneous, coordinated techniques—the Lab will increase efficiency, compatibility, flexibility, integration, and effectiveness.

For nearly five decades, APL's Strategic Nuclear Ballistic Missile Submarine Security Technology Program has protected the sea-based leg of the national strategic nuclear deterrent. (U.S. Navy)

Sea Control

We support U.S. Navy and joint service missions, delivering essential capabilities to project military power on, under, and above the seas. Building on our significant record of critical contributions to undersea warfare challenges, we have broadened the scope of our efforts to include developing and fielding innovative, effective solutions to provide global access for U.S. naval forces and to deny adversaries the effective use of the maritime domain. APL contributions are focused in four key areas: enhanced maritime domain situational awareness, kinetic and non-kinetic effects to deter aggressors and deescalate hostilities, force survivability against near-peer threats, and effective and affordable rapid prototyping and modernization.

Christopher Watkins
Mission Area Executive

SSBN Security Technology Program

The Strategic Nuclear Ballistic Missile Submarine (SSBN) Security Technology Program (SSTP) has, since 1969, protected the sea-based leg of the national strategic nuclear deterrent by preventing technological surprises. In addition to numerous technical projects, the program has added emphasis to analysis, assessment, and reporting on SSBN operations.

There has been a highly positive response to the detailed and comprehensive Patrol Security Debriefs on individual patrol behaviors related to stealth aspects of the strategic deterrence mission and timely discussions with submarine crews. Individual crews have recommended innovative and effective new practices with their better understanding of the physics of submarine detection and mission requirements. SSBN force commanders have used SSTP results to improve patrol guidance and force employment. Additionally, submarine force leadership now considers SSTP's assessment and debriefs an integral part of the ballistic missile submarine patrol cycle.

Operator-Machine Interface (OMI) Working Group

Fleet sonar operators from the submarine, surface, and surveillance communities are increasingly tasked to operate each other's unique systems. To improve operator performance even with reduced development and training costs, APL leads the Navy's OMI Working Group. The group develops common user interfaces for submarine, surface, and surveillance systems. Collaborating with the fleet and working with system developers, the OMI Working Group brings to life advanced concepts for detection, analysis, and exploitation of modern submarine acoustic signatures. Standardizing displays, procedures, and training products across each community enables the warfighter to best employ these complex systems in complex scenarios.

Pandarra Wave 15

APL directly engaged with leadership of the Navy's Seventh Fleet and their staffs to identify performance gaps in high-priority warfighting missions and develop concepts to mitigate those gaps. One of the first projects to stem from this collaboration was the Pandarra Wave 15 (PW15) fleet experiment, which successfully tested concepts and systems against the most advanced over-the-horizon radar systems. It directly illustrated warfighting gaps and opportunities to adapt existing technology and products. Part of the success came from APL's opportunity to embed a former special assistant to the Seventh Fleet on the team that conceptualized, planned, and executed PW15. The success of PW15 has resulted in several opportunities to test other technologies used by the Seventh Fleet.

CRACUNS

The CRACUNS (Corrosion Resistant Aerial Covert Unmanned Nautical System) concept unmanned aerial vehicle is an example of using innovative additive manufacturing techniques to support specific mission payloads. We achieve superior performance at lower cost by fabricating inexpensive, customized vehicles optimized for the specific mission instead of modifying (suboptimizing) payloads to fit existing vehicles. CRACUNS is designed to survive for extended periods while submerged at 200 feet and to be released remotely to float to the surface, take off, and execute an autonomous mission.

APL plays a key role in developing and fielding systems to measure a submarine's operational characteristics, as well as the physical environment around the boat. (U.S. Navy)

Enhanced Environmental Awareness Tools for Submarines

The SSBN Security Technology Program (SSTP) and the SSN/SSGN Security Program (S3P) are partnering to develop, validate, and install equipment on board U.S. submarines to better measure the operational characteristics of the boat as well as the physical environment around the boat. These measurements determine the impact of the boat on the surrounding environment for use both in real time by the boat's crew and post-mission by the Navy as part of its planning for all assets.

This includes developing and validating robust sensors; an adaptable data collection and processing architecture; and an adaptable data processing, display, and control system to be delivered to select boats. These efforts will also improve the performance and robustness of environmental measurement sensors for use in other Navy environmental tests and for the eventual incorporation of the sensors into the submarine-based system.

The USS Kentucky launches a Trident II D-5 ballistic missile as part of a successful Demonstration and Shakedown Operation. APL plays a key role in Navy DASOs, which validate the readiness and effectiveness of an SSBN's crew and weapon system. (U.S. Navy)

Strategic Deterrence

For more than 50 years, we have made vital contributions to the U.S. Navy's Fleet Ballistic Missile program. We are rising to the challenge of redefining strategic systems from the legacy nuclear mission to a broad set of responses to current and future national security challenges. APL demonstrates unequaled expertise in system development, testing, and evaluation for the SSBN mission, and we are applying that knowledge to the newly expanded roles of strategic systems in the Department of Defense.

Stephen Lewia
Mission Area Executive

Twin Trident Launches Cap Successful DASO

An APL team worked for two months on the West Coast to assist the Navy in conducting a Demonstration and Shakedown Operation (DASO) for a newly overhauled Fleet Ballistic Missile Submarine (SSBN), the USS Kentucky (SSBN 737). The DASO—the 26th D5 operation that APL has led for the Navy—culminated in the successful launch of two Trident II D-5 test missiles from a launch point off the coast of California. The APL team assisted in every phase of the operation for the SSBN mission, including the test missile on-load, the weapons system maintenance, the at-sea training operations, the launch, and the post-launch evaluation. APL staff members also

provided real-time performance evaluation assessments at all key test and range locations, including aboard the USS Kentucky, the Operations Control Room at Point Mugu Sea Range, aboard the Launch Area Support Ship, and aboard the Navy Mobile Instrumentation System ship monitoring the terminal area in the western Pacific. Other staff members back at APL's main campus supported data processing and analysis.

Discrete Velocity Boltzmann Modeling

We developed a new type of computational model for high-speed vehicles; this discrete velocity Boltzmann model permits modeling of airflow characteristics with arbitrary Mach numbers (speeds) and Knudsen numbers (altitudes). This approach, which is similar in spirit to lattice Boltzmann modeling (LBM), allows us to overcome the speed/altitude limitations associated with conventional LBM while retaining many of its key benefits, such as its amenability to parallel processing, simple setup, and time accuracy. Retaining the higher-order physics is necessary to increase the accessible range of speed/altitude; correspondingly, it makes the model more computationally intensive. To efficiently tackle problems, APL is combining this approach with traditional computational fluid dynamics solvers to solve flows that vary from atmospheric pressures to high vacuum. The Lab is using this technique for efforts that involve both hypersonic and rarefied flows. An internally funded project focuses on the deployment of a blast-fragment warhead from a hypersonic delivery vehicle, and a sponsored program focuses on the effect of gas-impingement on a warhead deployed from a maneuvering exoatmospheric platform.

Missile Range Requirements Study

APL established the Future Visions Working Group to determine a program plan that will address key risk areas for affordable submarine-launched ballistic missile sustainment through the service life of the Ohio Replacement SSBN, which ends in 2084. One of the group's objectives was to identify potential requirements trades that would enhance system affordability. In support of this effort, the Missile Range Requirements Study explored the effects on system range, target coverage, patrol area, and patrol schedule as various missile parameters such as size, propellant type, and maximum payload are relaxed. The range study invoked sophisticated geospatial Boolean operations to incorporate the numerous existing system constraints as well as those associated with modifying the aforementioned parameters. The conclusions drawn from the study provided valuable insight into the sensitivity of patrol area location and patrol operations on missile range. Moreover, the results of the study continue to serve as a metric for the ongoing system studies.

Physics-Based Modeling to Reduce Large-Scale Testing

Historically, submarine weapons systems required elaborate large-scale surfaced and/or submerged launch test programs, and many years of testing prior to their deployment on submarines. The predictive capacity of computer-based launch models was limited due to available computing resources and a reliance on empirical tuning factors obtained from the large-scale tests. APL has taken advantage of increased computing capacity and enhanced simulation tools to develop detailed physics-based eject and underwater launch models that do not depend on empirical factors. These models have greatly improved predictive capability. The goal is to validate the models through the use of focused subscale testing and limited-scope, full-scale tests, thus decreasing the time and funding required to assess and field new systems.

Strategic Deterrence Outreach

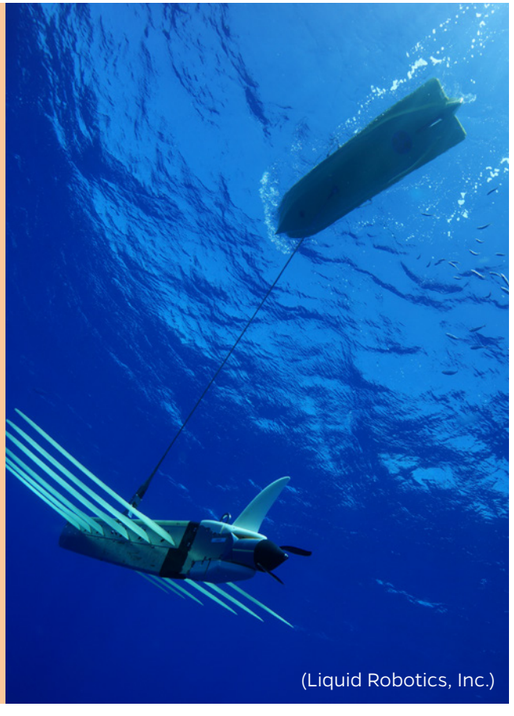
APL's new Strategic Deterrence Outreach Program Area is bolstering support across the deterrence mission space. Initially, this work is focusing on better coordination of the mission planning activity that APL provides to U.S. Strategic Command and nuclear and conventional long-range weapon system support for the Navy and Air Force. In addition to strengthening internal collaboration—specifically in the areas of national command, control, and communications (NC3); survivability and security; and strategic system acquisition—APL is reaching out to external organizations that also support the strategic mission.

Wave Glider Range Instrumentation

In an ongoing effort to increase efficiency and robustness of systems designed to collect Trident missile flight test data in the ocean, APL engineers have begun to outfit Wave Glider autonomous vehicles with suites of specialized payloads. The Wave Glider, a wave- and solar-powered ocean robot designed and manufactured by Liquid Robotics, can navigate severe conditions and provide near limitless on-station time. In the first demonstration—during a Demonstration and Shakedown Operation in November 2015—APL engineers captured data (such as missile telemetry, acoustic communications, and area weather) that is currently being recorded by manned sensors on ships. Success during this demonstration and subsequent planned tests could lead to significant cost savings for the Navy as well as the Air Force, which has also has expressed interest in APL's Wave Glider–based testing.

Gathering Data

Special engineering tests are often conducted as part of a DASO. For this operation, APL engineers deployed a Wave Glider—a paddleboard-like vehicle that is propelled solely by ocean waves—in the launch area. An APL-designed instrumentation suite was integrated onto the Wave Glider with acoustic, telemetry, and optical sensors to test the feasibility of using such a vehicle as a test instrumentation platform.



(Liquid Robotics, Inc.)

Space Exploration

NASA's New Horizons spacecraft, built and operated at APL, provided the first close-up views of Pluto and its moons in a spectacular and historic July 2015 flyby.

Earth, Meet Pluto!

Billions of miles from home and months removed from its historic July 14 flight past Pluto, NASA's New Horizons spacecraft is already speeding toward its next potential target, a smaller Pluto-like object in the Kuiper Belt with the unassuming tag of 2014 MU69.

But every week, the APL-built spacecraft sends back pictures and data that remind us of the largest, highest-profile event in the Laboratory's storied space exploration history—when a small world on the solar system's outskirts captured our hearts, thanks to an APL-led team of government, academic, and commercial partners determined to expand the frontiers of science and explore an entirely new realm of the solar system.

APL designed, built, and operates the New Horizons spacecraft and manages the mission for NASA. The spacecraft launched in January 2006, got a gravity boost from (and scientific look at) Jupiter in February 2007, and then cruised across deep space in record time for its reconnaissance of Pluto. New Horizons traveled farther than any other spacecraft to reach its primary target—and while it spent about two-thirds of that journey in hibernation, the team at APL and elsewhere was designing and practicing every maneuver and science operation of the Pluto encounter, and getting to know the spacecraft inside and out.

That preparation really paid off just before the flyby. On July 4, while trying to process commands from home and compress stored science data at the same time, the spacecraft's main computer overloaded and, as designed, switched to its backup processor. This put New Horizons into a "safe mode" in which it stops performing science, points to Earth, and quietly awaits word from operators on the next move.

Those moves were fast and thorough; APL engineers immediately identified the problem and reestablished contact within two hours. By July 7, the command set for the flyby—the critical directions for New Horizons' science instruments—was reloaded and ready to go. The recovery was flawless—and with so little time left, it had to be.

For the week of July 12–18, APL's Kossiakoff Center was Pluto Central. Nearly 250 members of the media, 1,600 guests, and hundreds of APL staff members were on hand for panel discussions, press conferences, and related activities; a full NASA TV set was built on the auditorium floor for flyby coverage that was broadcast and webcast to the world.

Not designed to collect images and transmit data at the same time, New Horizons was actually out of contact with Earth during its closest approach to Pluto at approximately 7:50 a.m. EDT on July 14. But the team, joined by more than 1,000 Kossiakoff Center guests and an international TV audience, marked the flyby with a raucous countdown that rivaled New Year's Eve in Times Square. Network morning shows beamed live images of U.S. flags waving and cheers and hugs around the room.

Later that morning, the team revealed a stunning, iconic image of Pluto, the last photo New Horizons took and transmitted before entering flyby silence. But the most critical transmission on July 14 did not include a picture; it was the burst of telemetry, set to arrive in Mission Ops just before 9 p.m., indicating the spacecraft was healthy and did its job. The suspense was short-lived, as the transmission—sent from New Horizons more than four hours earlier—came right on time.

Shortly after, the operations team walked across to the APL campus to the packed Kossiakoff Center auditorium, where they received a standing ovation to kick off a press conference that more resembled a Super Bowl celebration. All that was missing was a trophy and a call from the White House—though President Obama did tweet his congratulations to NASA and the team. NASA officials said New Horizons provided inspiration that would keep interest strong for the next generation to make their own "giant leaps," calling the mission a historic win for science and exploration and a true example of teamwork and collaboration.

Time for Science

The first close-up pictures, showing Pluto's surface and some of its moons in incredible detail, came back on July 15. Over the next several days and months, the science team scoured data and images of Pluto that revealed nitrogen ice flowing across the surface, mountain ranges that rivaled the Rockies, detailed structure in Pluto's atmosphere, and a vast, craterless, heart-shaped plain that might still be geologically active.

All of that data—about 50 gigabits' worth—is expected back by fall 2016.

In August, the team recommended to NASA a potential post-Pluto flyby target—a small Kuiper Belt object known as 2014 MU69 that New Horizons could reach on January 1, 2019, provided NASA approves an extended mission. The exploration and unprecedented discovery continue.

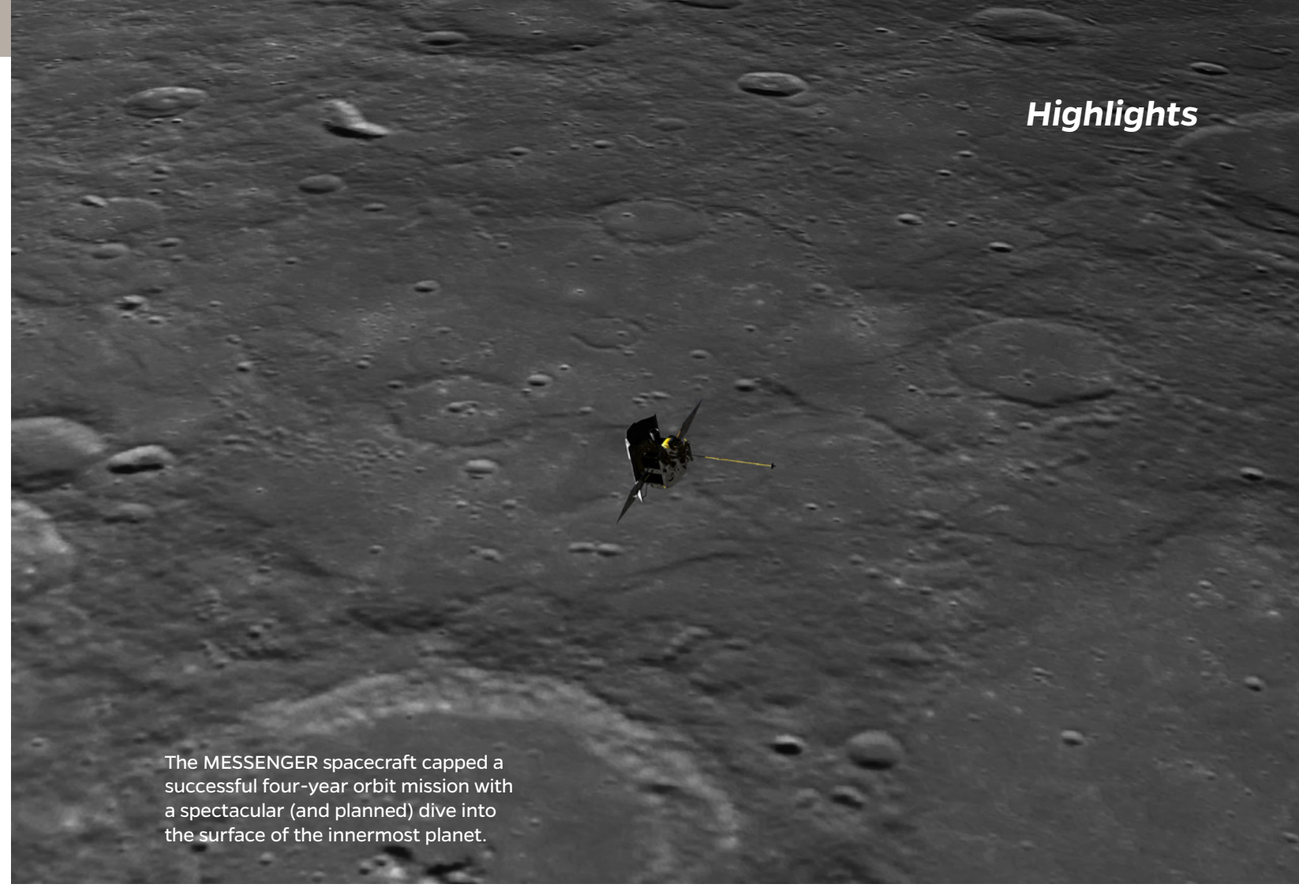
Pluto Popularity

The New Horizons Pluto flyby was one of NASA's most successful media operations ever, with more than 14,000 media reports from July 14 to 20, and Pluto images graced the front page of nearly 450 newspapers worldwide on July 14. On social media, according to NASA, New Horizons tweets and replies made 70 million impressions on Twitter, and New Horizons/Pluto posts reached 144 million Facebook users. In the hour before the Pluto flyby, 42 percent of all traffic on government websites was at www.nasa.gov.

Incredible Aim

Timing and accuracy were critical for all New Horizons flyby observations since commands for the science observations were stored in the spacecraft's computers and programmed to "execute" at exact times. To guide New Horizons to the right place and time, the team used a combination of radio-tracking data of the spacecraft and, in the months before the flyby, range-to-Pluto measurements made by optical navigation images of Pluto taken by New Horizons itself.

So after 9.5 years and 3 billion miles, how did they do? Aiming for a 60- by 90-mile box near Pluto, the team almost guided New Horizons through the center of it—accuracy that mission managers compared to hitting a hole-in-one from New York to Los Angeles.



The MESSENGER spacecraft capped a successful four-year orbit mission with a spectacular (and planned) dive into the surface of the innermost planet.

Civil Space

We make critical contributions to the missions of our major sponsor, NASA, to meet the challenges of space science. Our work includes conducting research and space exploration; development and application of space science, engineering, and technology; and production of one-of-a-kind spacecraft, instruments, and subsystems.

Kurt Lindstrom
Mission Area Executive

MESSENGER Ends with Impact

Out of fuel and its mission very well accomplished, the APL-built-and-operated MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft smacked into the surface of Mercury—as predicted—on April 30. MESSENGER was launched on August 3, 2004; began orbiting Mercury on March 18, 2011; and completed its primary science objectives by March 2012. Because MESSENGER's initial discoveries raised important new questions and the payload remained healthy, the mission was extended twice, allowing the spacecraft to make observations from extraordinarily low altitudes and capture images and information about the planet in unprecedented detail. With no way to increase its altitude, MESSENGER was finally unable to resist the perturbations to its orbit by the Sun's gravitational pull, and it slammed into Mercury's surface at around 8,750 miles per hour.

Balloon Science: High-Altitude Research Platform

The APL High-Altitude Research Platform (HARP) is a balloon-borne gondola capable of carrying multiple scientific payloads into the stratosphere. Picking up on the successful Balloon Observation Platform for Planetary Science (BOPPS) gondola mission of 2014 to observe three Oort Cloud comets, HARP was recovered virtually intact after landing in the Texas desert and refitted in 2015 for use as the Stratospheric Terahertz Observatory-2, which will observe the interstellar medium.

NASA Approves a Europa Mission

Jupiter's icy moon Europa is considered one of the most promising places in the solar system to search for signs of life under its frozen ocean crust, and a new NASA mission to explore this potential—developed by APL in partnership with NASA's Jet Propulsion Laboratory—moved from concept to development. APL holds key leadership roles on the mission and is contributing two science instruments: the Plasma Instrument for Magnetic Sounding, which scientists will use to determine the thickness of the ice that encases Europa as well as the depth and salinity of its ocean, and the Europa Imaging System, a high-resolution camera that will offer near-global and targeted coverage. The mission plan calls for launch in the early 2020s and arrival at Jupiter after a journey of several years.

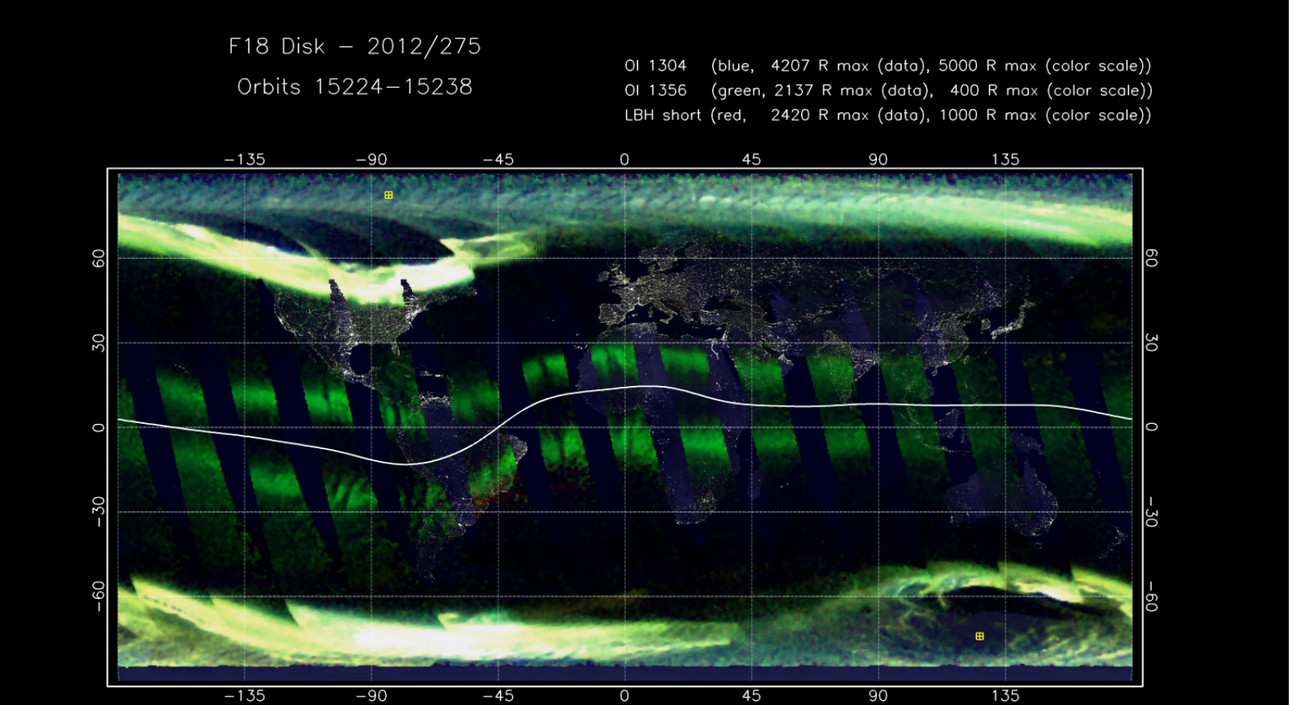
Touching the Sun

APL's work on Solar Probe Plus—which will be the first spacecraft to journey into the Sun's atmosphere to find out why the solar corona is so much hotter than the solar surface and how the solar wind accelerates—moved into advanced development. During its seven-year mission, Solar Probe Plus will travel much closer to the Sun's surface—just 3.8 million miles—to repeatedly obtain detailed observations of the magnetic field, plasma, and accelerated particles in the region of the Sun that generates the solar wind. In fact, by making direct measurements inside the region where the solar wind is created and where some of the most hazardous solar energetic particles are energized, Solar Probe Plus aims to improve our ability to characterize and forecast the dynamics of the heliosphere and the resulting effect on Earth's radiation environment. These effects influence space weather conditions on Earth and in the orbital space where future explorers will live and work.

Deflecting an Asteroid

The Asteroid Impact and Deflection Assessment (AIDA) mission is being studied as the first space experiment to demonstrate asteroid impact hazard mitigation by using a kinetic impactor to deflect an asteroid. AIDA is an international cooperative effort between NASA and the European Space Agency (ESA) consisting of two mission elements: the NASA Double Asteroid Redirection Test (DART) mission, to be built by APL, and the ESA Asteroid Impact Mission (AIM) rendezvous mission. The DART design builds on APL's long-standing missile defense and deep-space heritage. With planned launch scheduled for December 2020, AIDA's target will be the binary asteroid Didymos in October 2022. The DART impact on the secondary member of the binary at 6 kilometers per second will alter the binary orbit period, which can be measured by Earth-based observatories.

Development is well under way on Solar Probe Plus, set to launch in 2018 and travel closer to the Sun's surface than any other spacecraft—and revolutionize what we know about solar properties and space weather.



APL's Special Sensor Ultraviolet Spectrographic Imager (SSUSI), flying on Defense Meteorological Satellite Program spacecraft, provides unique, critical data on the global ionosphere, aurora, and upper atmosphere.

National Security Space

Our programs focus on space solutions to critical military problems. We leverage significant experience in both civilian and national security space programs, as well as other technical areas across the Lab, to develop and conduct innovative experimental missions, build space instruments, and produce new applications to meet warfighter needs.

NanoBridge

In September 2015—almost two years after launch of the APL-built Multimission Bus Demonstration (MBD)/Vector CubeSat—APL completed NanoBridge, a 3U-sized technical demonstration CubeSat design. NanoBridge encompasses the lessons learned from APL's heritage of spacecraft development as well as the flexibility to host multiple types of payloads. The APL team also produced the documentation for an experienced external manufacturer to build the NanoBridge spacecraft bus.

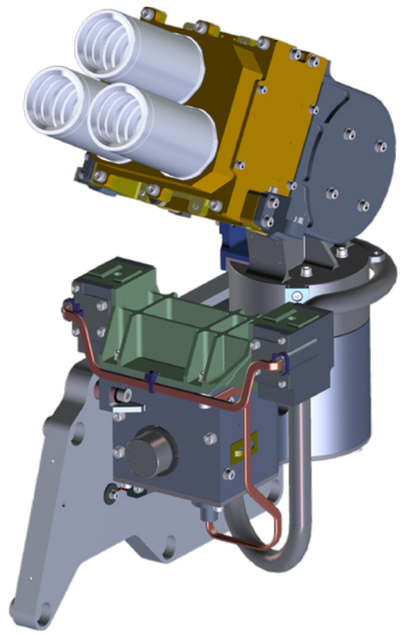
Joe Suter
Mission Area Executive

Space-Based Kill Assessment (SKA)

APL is developing, integrating, and testing the sensors for the Missile Defense Agency's SKA experiment—a network of small sensors, to be hosted on commercial satellites, that will be able to detect the energy created when a Ballistic Missile Defense System interceptor impacts a ballistic missile threat. SKA combines low-cost sensor capability with a once-in-a-decade opportunity for hosting sensors on commercial space platforms. Currently through the assembly and integration phase, the SKA experiment is expected to be on orbit in 2017.

Responsive Environmental Assessment Commercially Hosted (REACH) Payload Experiment

As the Defense Meteorological Satellite Program ends, the U.S. Air Force seeks innovative options to sense the energetic charged particles in space that can harm critical satellites. APL teamed with several partners in a study for the Space and Missile Systems Center (SMC) Hosted Payload Office in 2013 to evaluate and design a "hosted payload" approach to place dosimeters that are sensitive to different particle populations on different satellites as a low-cost way to cover the global radiation environment. A hosted payload performs a function unrelated to its satellite's primary mission, and yet it depends on the satellite "host" for power and telemetry. On the basis of the study's findings, SMC/Advanced Systems and Development Directorate has funded an experiment to fly dosimeters in low-Earth orbit; these sensors are on track for deployment in 2016–17.



SKA experiment sensor

Special Sensor Ultraviolet Spectrographic Imager

APL built five Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instruments for the Defense Meteorological Satellite Program (DMSP) Block 5D-3 satellites, which are in nearly polar, Sun-synchronous orbits. SSUSI measures Earth's upper atmosphere ultraviolet (UV) emissions in five wavelength bands. Four SSUSI instruments were launched between 2003 and 2014; the SSUSI program provides data about the upper atmospheric response to the Sun over a large portion of the solar cycle. The UV images and the derived environmental data provide the 557th Weather Wing (Offutt Air Force Base, Omaha) with near real-time information that can be utilized in a number of applications, such as maintenance of high-frequency communication links and related systems.

National Security Analysis

APL analyses have identified, quantified, and prioritized opportunities to address time-critical targets across multiple domains—space, air, land, and sea.

We combine technical knowledge with analysis to find tomorrow's solutions to national security, space, and health challenges. Our analysis informs senior decision makers across the government on national policy, technology, acquisition, exercises and experimentation, and complex current and future operations.

Preston Dunlap
Mission Area Executive

Defeating Time-Critical Targets

Time-critical targets pose grave challenges, which demand rapid detection and neutralization. Using deception and speed, these targets avoid detection or confuse opponents. Ranging from air defenses to mobile platforms, to terrorists, to long-range missile systems carrying potentially devastating payloads, these targets represent both diverse and complex threats. At the request of the Undersecretary of Defense for Acquisition, Technology, and Logistics, APL led analyses that identified, quantified, and prioritized opportunities to address time-critical targets across multiple domains—space, air, land, and sea. Our effort informed Department of Defense investment decisions and combatant commander operational plans, ranging from warning, detection, exploitation, and targeting and tracking, to prosecution of threats. Ongoing analysis and systems engineering are shaping exercises and experiments planned for 2016 that will test these concepts and emerging capabilities, including innovative technologies being designed and integrated by APL for the Office of the Secretary of Defense.

Adapting to Change in Modern Ground Warfare

The Army must ensure that its soldiers can adapt to the increasingly complex and dynamic nature of modern warfare. To support this goal, APL analyzed the Army's adaptive leadership curriculum, practices, and programs to identify factors that contribute to battlefield adaptability. APL's "state-of-the-practice" analysis, conducted for the Army's Asymmetric Warfare Group, examined adaptability at the individual soldier level through a detailed review of existing doctrine and training as well as expert interviews and field research. APL's team developed an operational definition of adaptability and metrics to measure it at the individual level. The Lab's future research will build on its findings to help the Army quantify individual and leader characteristics that will be critical for the Army's future.

APL analyses are helping the Navy prioritize investments in research, development, and acquisition, as well as develop tactics to strengthen the nation's ability to project power. (U.S. Navy)

Projecting Maritime Power in Denied Environments

Increasingly, U.S. adversaries are pursuing advanced cruise and ballistic missile technology designed to deny, disrupt, or destroy ships and hinder our ability to project maritime power. The National Security Analysis Mission Area, in close collaboration with the Air and Missile Defense Mission Area, continues to conduct critical analyses of these growing threats and ways to counter them for the Chief of Naval Operations. Leveraging decades of expertise in air and missile defense, analysis, and modeling and simulation, APL's multidisciplinary team conducted high-fidelity, system-of-systems analyses of the threats and the innovative approaches to counter them. Our analyses examined existing, planned, and potential future U.S. systems and helped the Navy prioritize investments in research, development, and acquisition, as well as develop tactics to strengthen the nation's ability to project power into the future.

Delivering Impactful Analysis to Decision Makers

As a part of APL's interest in making a greater impact with its technical expertise, the Lab continued to make internal investments in the analysis of ongoing and future critical challenges to the nation. The analysis initiatives in 2015 in some instances built on the results of studies conducted in 2014, including follow-on case studies of development projects that had to be shelved by other nations in the face of budget declines but have since been implemented several years after initial development. Analysis of the nation's nuclear weapons also continued, with a focus on the current state of tactical nuclear weapons.

Impending decisions for the Navy in acquiring the future fleet prompted a specific analysis of the trade space available to decision makers who must manage the shipbuilding budget. With due consideration for alternative funding scenarios and operational needs, analysts outlined future force architectures under different potential scenarios and the benefits and drawbacks that come with each option.

Current challenges for homeland defense and disaster response were also featured in the 2015 independent analysis portfolio, with a particular focus on responding to cyberattacks. Drawing from his experience coordinating the Department of Defense's response to Superstorm Sandy as the assistant secretary of defense for homeland defense and America's security affairs, APL Senior Fellow Paul Stockton examined important potential shortfalls in the nation's ability to respond to a cyberattack on the power system and contrasted that response with the current response framework for natural disasters.

APL studies of Russian actions in Crimea and Ukraine, and recommendations on responses to these actions, are helping U.S. Special Operations Command and U.S. European Command address the threat posed by unconventional warfare. (Wikipedia/Creative Commons)

Fighting in the Gray Zone: The New Unconventional Warfare

Unconventional warfare is a practice that seeks military victory through acquiescence, capitulation, or clandestine support, and it has been increasingly adopted by Russia, China, Iran, and Islamists. For example, when Russians crossed the border to fight with rebels in eastern Ukraine in early 2015, Moscow said soldiers had not been deployed but had gone on their own vacation time. In another brazen display of the tactic, Russian soldiers without insignia took control in Crimea in March 2015. The U.S. Army Special Operations Command (USASOC) released a report in November 2014 that identified gaps in U.S. capabilities to meet this challenge. To address the threat posed by unconventional warfare, USASOC asked APL to study Russian actions in Crimea and Ukraine and recommend ways to address this threat. After reviewing firsthand accounts, official reports, intelligence updates, and State Department documents providing detailed accounts of the political conflicts that framed the war, APL analysts produced a report that helped shape Special Operations Forces' and NATO's ongoing deterrence efforts in Eastern Europe.

Research and Exploratory Development

APL measurements of forces soldiers might endure when an improvised explosive device strikes under their vehicle are key to the Army's Warrior Injury Assessment Manikin (WIAMan) project to design a warrior-representative test dummy.

We leverage science, technology, and systems engineering to provide highly innovative, affordable, and timely solutions to critical national challenges. We support other APL mission areas in cross-enterprise initiatives of vital importance to the nation and the Laboratory by making technology breakthroughs and transitioning solutions to our sponsors. Our basic and applied research and technology development provides the foundation for many forward-looking internal and sponsored programs and initiatives.

Sezin Palmer
Mission Area Executive

Warrior Injury Assessment Manikin

APL is helping the Army learn how soldiers respond to explosions caused by improvised explosive devices (IEDs) and mines while inside a vehicle—and ultimately to improve safety on the battlefield. APL completed the first 3-D simulation of a "dummy" that will measure forces from the kind of blasts that soldiers endure when an IED strikes under their vehicle. This is the latest accomplishment in the U.S. Army Research Development and Engineering Command's Warrior Injury Assessment Manikin (WIAMan) project to design an anthropomorphic test device (ATD)—a warrior-representative test dummy—and associated injury-assessment tools for use in live-fire tests and vehicle development. In 2015, APL delivered the first-ever Biofidelity Response Corridor (BRC), which is a measure of an ATD's capability to respond as a human does during an impact. The BRC data will be used to create the physical WIAMan device and to support Army efforts to create software that will allow it to digitally perform blast-response tests and collect the results.

Hypersonic Materials and Structures

APL researchers are making critical strides in understanding hypersonic-flight materials. Starting with tools to model basic material interactions and simulate how these systems respond to hypersonic flight, APL evaluated various in-house and vendor-processed materials to gain insight into the behavior and characteristics of their different constituents. This included a close look at the interactions of the constituent layers and basic properties of these materials, particularly at elevated temperatures—and with emphasis on the multi-functional barrier (MFB) layer, an outside coating fundamental to thermal balance. The Lab applied these MFB materials to both carbon-carbon substrates and iridium coatings to validate chemical compatibility to 1,900 degrees Celsius in a vacuum and to 1,700 degrees C in the open air. To study the oxidation barrier, APL electroplated iridium on carbon-carbon substrates and heated it to make sure there was no measurable carbon diffusion through the iridium at temperatures up to 1,900 degrees C in a high-vacuum environment—to check that unintended reactions were not taking place.

Quantum Physics and Computing

In theory, quantum computers will perform selected computations well beyond the capabilities of the fastest supercomputers. But for a quantum computer to become real, physicists face two extreme challenges: Quantum bits (known as “qubits”) must not only be controlled with nearly perfect precision for the computation to be successful, they must also be completely isolated from stray noise. But these simultaneous needs are at odds and have prevented the development of large-scale quantum systems. APL scientists have been leading a multilaboratory theoretical research effort for the Intelligence Advanced Research Projects Activity that has led both to emergent understanding of noise in quantum systems and to new methods for understanding and mitigating the sources of noise. Some of these methods are already being implemented by experimental collaborators and are giving us insight into quantum systems.

Microbial Defense Initiative

Building on capabilities APL developed as part of the Defense Advanced Research Projects Agency Prophecy program—under which APL is exploring the evolution of viruses in the hopes of predicting viral mutations and ultimately developing drugs and vaccines before people need them—the Lab is looking hard at the technological gaps related to therapeutic development and emergency response to an infectious disease outbreak. APL’s microbial defense strategic independent research and development project is focused on single-cell analysis to illuminate new therapeutic targets, genetic data visualization tools and automated analysis, technologies to address antibiotic resistance, and methods to eliminate cold-chain storage for critical products. Over the past year, the team made progress in microfluidic droplet sorting, design of high-affinity binding proteins for bacterial antigens, bacteriophage studies, and cell-free technologies that can potentially be used for rapid therapeutic production. One significant accomplishment was a single-cell analysis that could lead to isolation of therapeutic antibodies, vaccine testing, or critical insights into viral infection for novel pathogens.

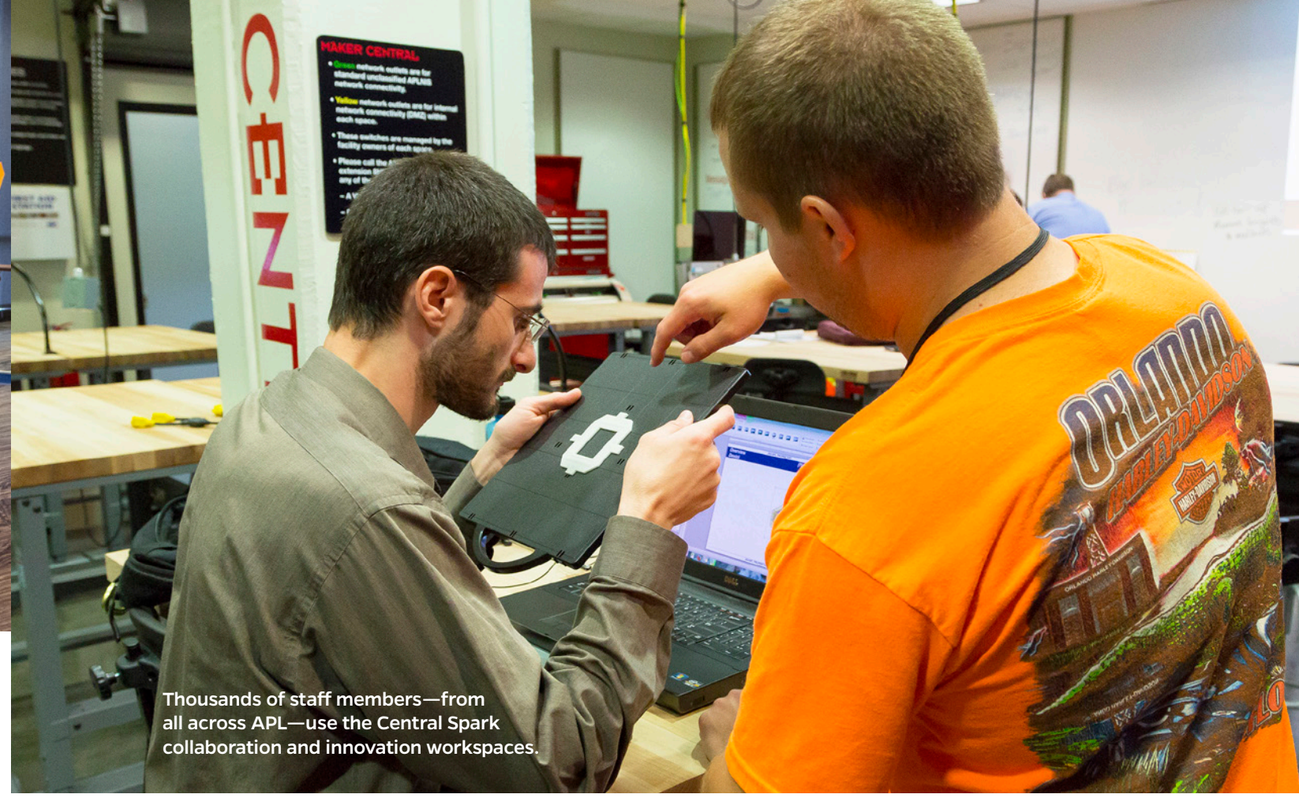
APL researchers are looking hard at the technological gaps related to therapeutic development and emergency response to an infectious disease outbreak.

APL metamaterials technology is being used to isolate signals in multiantenna platforms, a key element of electronic attack systems.

Metamaterials Technology

Most electronic attack applications require a multiantenna platform to receive and broadcast microwave signals—and the difference in these respective signals makes it critical that the antennas be electrically isolated from each other. APL has developed metamaterial technology that demonstrates an order-of-magnitude improvement over existing isolation materials such as magnetic radar-absorbing coatings. The Lab has also taken this approach beyond antenna isolation and developed metamaterials for low-profile and conformal radio frequency/microwave antennas used for communications that require dramatic reductions in electronics complexity, power, and system weight. APL’s analytical modeling approach is also reducing the time required for optimal design and simulation of metasurfaces, including structures that can be used for antenna isolation and metamaterial absorbers. Beyond the microwave domain, APL also extended its metamaterials capability into the infrared, creating novel dynamic infrared metasurfaces by using liquid crystals and phase change materials in collaboration with Duke University.

APL introduced the Project Catalyst innovation initiative to ramp up investments in high-risk, transformative ideas and technologies.



Thousands of staff members—from all across APL—use the Central Spark collaboration and innovation workspaces.

A Culture of Innovation

APL was built on a foundation of innovation and creative thinking and the ability to translate ideas into effective technical solutions. The Laboratory has reinvigorated its commitment to creating a culture of innovation through a series of coordinated, enterprise-level initiatives. This year, APL challenged its staff members to look toward the next decade and beyond, while building on programs to promote staff member collaboration and grow the number of inventions, disclosures, and opportunities for sponsors.

Project Catalyst

In 2015, the Lab launched a major initiative to increase investments in high-risk, transformational ideas and technologies. The initiative—Project Catalyst—builds on the success of the Lab's Ignition Grants program and allows staff members to compete for significant funding to advance ideas that could impact the future work of the Laboratory. When the program is fully implemented, it will invest an additional $5.5 million per year in game-changing technologies and innovations.

Project Catalyst is an integral part of APL's new, long-range strategy, which articulates the Lab's core purpose and values, and establishes the strategic goal for APL to create defining innovations that ensure our nation's preeminence in the 21st century.

Ignition Grants—a successful program introduced in 2011 that provides seed funding for new ideas—are now a part of Project Catalyst. The ideas are improved and voted on through APL internal, online crowdsourcing. In 2015, 16 ideas were selected for funding from three different challenge areas—mobile applications, intelligent systems, and health care. More than 4,000 staff members have participated in Ignition Grants by submitting, collaborating on, or voting on ideas. Since its inception, the Ignition Grants program has greatly increased the Lab's number of invention disclosures and that number is expected to continue growing with the start of Project Catalyst. Project Catalyst builds on the success of the Ignition Grants program by adding two new levels of funding to address larger, more complex challenges. Combustion Grants provide the next-higher level of funding to allow staff members to explore novel ideas throughout the year. Propulsion Grants, which are the highest-level grants, provide significant, multiyear funding to breakthrough technologies and concepts that address specific challenges.

Central Spark

APL's innovation center—Central Spark—celebrated its first anniversary in 2015 with a week of events and hands-on activities that engaged staff members and showcased opportunities for collaboration. Central Spark was created from an Ignition Grant proposal and now includes six physical spaces on campus where staff members can meet, work on designs and ideas, build prototypes, create videos, and more. This year, more than 3,000 people made use of the tools and resources in Central Spark. Sponsors and stakeholders continue to be extremely engaged by this facility and its potential, and a number of inventions and concepts developed for sponsors resulted directly from Central Spark.

Tech Splash

To help share expertise, accomplishments, and capabilities across the organization, the Lab developed a video series called Tech Splash in 2013. These short, creative videos highlight information and ideas that may be useful in multiple domains across the Laboratory. Edited and produced in house, the videos are viewable on APL's intranet, and some are shared externally on the APL YouTube channel. In 2015, videos about the NASA New Horizons mission to Pluto and the Revolutionizing Prosthetics program received hundreds of thousands of views on YouTube.

Advanced Fabrication Facility

From rapid-response prototypes that address immediate needs in the field to years-long spacecraft design and fabrication, APL's wide-ranging systems engineering needs require a dedicated and talented team that can quickly turn innovative ideas into effective devices. Our comprehensive fabrication facilities deliver hardware systems through a variety of equipment and services, including complex machining and assembly, reverse engineering, additive manufacturing, and other unique capabilities.

Facilities and Capabilities

Maritime Systems Integration Facility

APL's Maritime Systems Integration Facility plays a critical role in final assembly and testing of large systems before they are deployed to the field for operational testing. The facility is outfitted to accommodate large system integration of vehicles, small watercraft, and other sea-going platforms such as buoys, towed arrays, and unmanned aerial and underwater vehicles.

Combat Systems Evaluation Laboratory

APL supports both Department of Defense and Department of Homeland Security operations in this upgraded facility, in which the Lab employs and validates prototypes that address a range of challenging warfighting requirements. The facility offers the potential to directly participate in exercises, operations, and remote maintenance actions to provide faster and more effective response to the warfighter and sponsors.

Facilities and Capabilities

Spacecraft Integration and Test Facility

APL's proven philosophy to "test as you fly" comes to life in our extensive integration, testing, and operations facilities, where we conduct a range of spacecraft life-cycle testing and operations under conditions ranging from ground handling through launch and orbit. APL offers thermal and dynamic environmental testing at all levels of flight hardware assembly, as well as significant vibration test laboratories, a space simulation laboratory, and other general mechanical test capabilities.

Technology Transfer

APL's Office of Technology Transfer (OTT) transforms our innovations into publicly available technologies. OTT helps launch start-up companies, issues licenses, and develops strategic partnerships aimed at translating APL inventions into commercially viable products that benefit society.

Internal Research and Development (IRAD)

The Laboratory funded 16 OTT IRAD projects, including a sensor for better detection of multiple impacts to a target and a nanotechnology platform that is being combined with Johns Hopkins Medicine's cutting-edge therapeutic strategies to create a drug-delivery system. Another IRAD team is developing a handheld system for rapid diagnostics of biological agents in far forward, severe environments.

Record Year

In FY 2015, APL innovators filed 274 invention disclosures, setting a record that surpassed the Lab's 2014 totals by five percent. Approximately 30 percent of this year's disclosures were submitted by first-time inventors—highlighting our ongoing effort to create a climate of challenge, discovery, and thought leadership.

Supporting Start-Ups and Technology Partnerships

APL formed one company and continues to support two recent start-ups, NextGen Forensic Sciences and Cognescenti Systems. The Lab also supports companies whose technologies are not directly derived from APL but have a strong connection, such as three Maryland firms (Defense Architecture Systems Inc., Link Labs, and Terbium Labs) started by a former APL researcher and entrepreneur.

In fact, our partnership with the Maryland Center for Entrepreneurship (MCE) continues to serve as a vehicle for APL to support start-ups. This year, two APL start-ups are using MCE-provided space and services, and six new local companies are seeking to enhance their technological capabilities with APL intellectual property.

Top Inventions

The Laboratory hosted its annual Achievement Awards in April 2015 to recognize work that benefits government sponsors and commercial needs. A project that encourages nerve growth was selected as the Invention of the Year. The Government Purpose Innovation Award went to a network defense technology that uses virtualized, sensor decoys to increase the scope, scale, and complexity for network attackers. Charles Kerechanin received the Master Inventor Award in recognition of the 11 patents he earned while working at APL.

OTT by the Numbers

Technology Transfer from October 2014 through September 2015

274	Inventions disclosed
89	Regular U.S., foreign, and provisional patent applications filed
35	U.S. patents issued
73	License agreements executed
1	Company created

University Collaboration

As a university affiliated research center and division of Johns Hopkins University (JHU), APL has many exciting opportunities to make the world healthier, safer, and more secure. We team with our Johns Hopkins partners and experts in other specialized fields to address a wide array of challenges and missions for our sponsors. These interdisciplinary collaborations reach across the full spectrum of the university and the Johns Hopkins Hospital, including the Whiting School of Engineering, the School of Medicine, the Krieger School of Arts and Sciences, the Nitze School of Advanced International Studies, the Bloomberg School of Public Health, and the Carey Business School.

Higher Education

The Laboratory has a strong commitment to continuing education. More than 180 APL staff members teach engineering, applied science, engineering management, technical management, and information technology courses within the Johns Hopkins Whiting School's Engineering for Professionals (EP) program. APL professional staff members also serve as program chairs for 10 of EP's 18 master's degree programs. These 10 programs account for more than 87 percent of EP enrollments.

APL-Based EP Programs

EP students can attend classes at APL, at the Johns Hopkins Homewood campus, or at five other regional locations. In addition, companies and organizations across the nation have educational partnerships with JHU, particularly in systems engineering. Online education is a growing focus of the EP program, with more than half of total course enrollments and 12 master's degree programs offered online.

These 10 programs—Applied and Computational Mathematics, Applied Physics, Computer Science, Cybersecurity, Electrical and Computer Engineering, Engineering Management, Information Systems Engineering, Space Systems Engineering, Systems Engineering, Technical Management—account for more than 87 percent of EP enrollments.

During the 2014–15 academic year, more than 3,000 students participated in the 10 APL-based EP programs, accounting for 6,935 course enrollments. More than 580 master's degrees were conferred by EP during the 2014–15 academic year. Since 1968, more than 1,350 APL staff members (and more than 16,700 other students) have received master's degrees from these programs.

SPUR Interns

APL and the Whiting School of Engineering have teamed up on the Summer Program in Under-graduate Research, also known as SPUR, which provides highly qualified engineering students with the opportunity to conduct research at APL. With generous support provided by Heather and Jim Murren, the program allows Whiting School interns to work on projects ranging from ballistic missile systems and computer vision to prosthetic limbs and secure mobile communications. The program—which included 10 participants in 2015—represents the university's commitment to integrating research and hands-on experiences into undergraduate education.

Discovery Awards

Four APL scientists were among the 76 Johns Hopkins researchers chosen for the first round of JHU Discovery Awards. The program—launched in 2015 by JHU President Ronald J. Daniels, Provost Robert C. Lieberman, and the deans and directors of the academic divisions—is part of a $15 million commitment to cross-university, faculty-led research over three years. Researchers could apply as part of teams for up to $100,000 to explore a new area of collaborative work, or request up to $150,000 in project planning funds to prepare for an externally funded large-scale grant or cooperative agreement. The program attracted 217 proposals, from which 23 teams, each composed of members from at least two Johns Hopkins divisions, received awards. APL researchers were on teams investigating High Throughput Discovery and Domestication of Bacteriophages for Human Microbiome Engineering; Sequencing-based Transcription Factor Binding Quantification for Synthetic Biology; and Transport of Diagnostic Laboratory Samples in the Nzoia District of Western Kenya using Unmanned Aerial Vehicles.

National Health

APL's National Health Program Area focuses on predicting and preventing illness, injury, and disease and rapidly responding to health challenges facing the nation. The program area's scientists and engineers work closely with our Johns Hopkins partners to solve a range of problems from discovery through system development and implementation; the Johns Hopkins Individualized Health Initiative (Hopkins inHealth), for example, has teamed APL with the University and Johns Hopkins Health System in a broad effort to create innovative tools that help providers and patients make better decisions when preventing and treating conditions such as cancer, cardiovascular disease, autoimmune disorders, and infectious disease—aiming to deliver the right care to the right person at the right time.

APL's Space Academy introduces middle school students to the people who design and conduct some of NASA's most exciting missions.

Community Involvement

APL joins the nation in tackling the critical challenge of inspiring and training the next generation of scientists and engineers. In 2015, the Lab's Science, Technology, Engineering, and Mathematics (STEM) education and outreach programs reached more than 3,500 students, parents, and teachers—thanks to the 300 APL volunteers working in counties throughout Maryland.

Space Academy

The New Horizons mission to Pluto was the topic for this year's Space Academy. Now in its 15th year, the Space Academy series, sponsored by APL and Discovery Education, takes Maryland middle school students behind the scenes of actual space missions and introduces them to the people who conduct some of NASA's most exciting projects.

Pipeline to the Future: College Interns

In 2015, more than 320 interns from 100 colleges and universities worked in APL's college intern programs, which provide practical work experience and an introduction to careers and work at APL. These interns ranged from freshmen to Ph.D. level, worked on projects across the Laboratory in every technical department, and had the opportunity to network throughout the summer at receptions, social events, seminars, and workshops..

The Girls Who Code program works to inspire, educate, and equip girls with the computing skills to pursue today's technological opportunities.

Girls Who Code

For the second year, a group of local middle and high school girls spent Tuesday evenings at APL learning both the science and art of computer coding from APL staff members. The program, called Girls Who Code, is part of a national organization that works to inspire, educate, and equip girls with the computing skills to pursue 21st century opportunities, with the ultimate goal of reaching gender parity in computing fields. This year, 19 girls participated in the program.

Maryland MESA

APL's Maryland Mathematics Engineering Science Achievement (MESA) is a precollege program designed to prepare students for academic and professional careers in STEM. Maryland MESA aims to increase the number of engineers, scientists, mathematicians, and related professionals at technical and management levels and serves as a driving force in encouraging and assisting minorities and females in achieving success in these fields. The program provides services and programs to more than 2,000 students and 121 teachers from across central Maryland.

Boys & Girls Club Tutoring

APL is continuing its partnership with the Boys & Girls Club of Metropolitan Baltimore to offer an afterschool math tutoring program to 19 middle school students. The program aims to increase the students' proficiency in math by using tactile and computer-based techniques. The students are also using Lego Mindstorm kits to gain an understanding of how math can be applied to solve real-world problems. The group is meeting once each week for 10 weeks in the fall and 10 weeks in the spring.

ASPIRE and College Prep

APL's Student Program to Inspire, Relate and Enrich (ASPIRE) included 113 APL mentors guiding a record 100 high school juniors and seniors, all working on real Lab projects and most planning to study STEM subjects in college. The Lab's College Prep Program—supporting academically talented students who have little or no exposure to the college application process—has "graduated" more than 140 students. Approximately 50 APL staff members gave more than 4,000 hours of volunteer time to support this program. More than 95 percent of program graduates are on track to earn a bachelor's degree and more than 15 program alumni have interned at APL.

Awards and Honors

Stamatios "Tom" Krimigis received the Smithsonian National Air and Space Museum Trophy for Lifetime Achievement, the museum's highest honor.

Louise Prockter received the Ronald Greeley Award for Distinguished Service from the Planetary Geology Division of the Geological Society of America.

Julia Dooher was named a 2015 Fellow of the Emerging Leaders in Biosecurity Initiative program.

Mark Hinton received the National Defense Industrial Association's Ground Robotics Technology Innovators award.

The Los Angeles-Las Vegas Section of the American Institute of Aeronautics and Astronautics chose Glen Fountain as the first recipient of its new Technical Excellence Award in recognition of his achievement as the program manager of the New Horizons mission to Pluto.

George Coles, Wale Akinpelu, Camille Daniel, Khadir Griffith, Anthony Watkins, and Anthony Plummer received Black Engineer of the Year Awards. Coles received a Research Leadership award; Griffith, Akinpelu, Daniel, and Watkins were named Science Spectrum Trailblazers; and Plummer was named Promising Engineer.

Jason Benkoski and Morgana Trexler (third and fifth from left, respectively) were named Outstanding Young Scientist and Outstanding Young Engineer, respectively, by the Maryland Academy of Sciences and the Maryland Science Center.

Fred Rosa was appointed a Senior Fellow of the Center for Cyber and Homeland Security at The George Washington University.

Wayne Pavalko received the Science Advisor of the Year award as well as the Navy Superior Civilian Service Award from the Office of Naval Research's Global Science Advisor program.

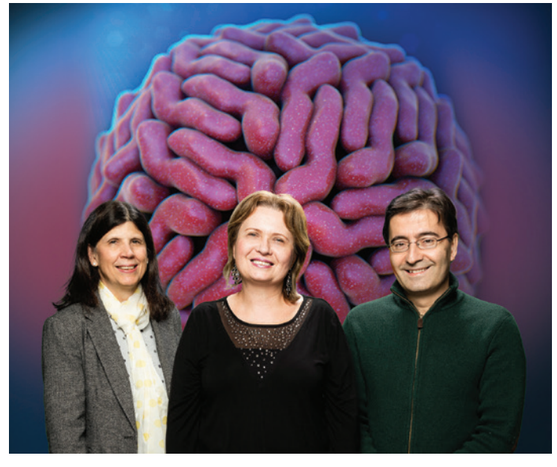
Hilary Hershey was among those honored at the Johns Hopkins Diversity Leadership Council's 13th annual Diversity Recognition Awards.

Four APL staff members—Danielle Hilliard, David Benigni, Stephanie Martin, and Uche Maple—graduated from Leadership Howard County, a program to empower individuals who live or work in Howard County to strengthen and transform the community.

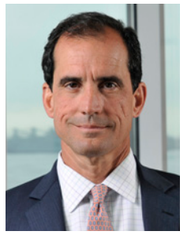
Hannah Susorney won the Stephen E. Dwornik Award for the best poster presentation made by a graduate student at the Lunar and Planetary Science Conference.

Nicole Krepps received the 2015 Rising Star Award during the NASA Cost Symposium at NASA Ames Research Center.

Linda Moniz, Anna Buczak, and Erhan Given were among select infectious-disease specialists invited to the White House in September to discuss a model they developed to forecast outbreaks of the dengue virus.



Board of Managers



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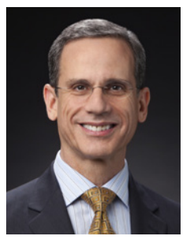
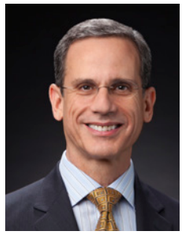
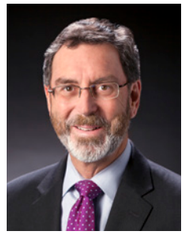


Ralph D. Semmel
Director, Johns Hopkins University Applied Physics Laboratory

Leadership



Ralph Semmel
Director



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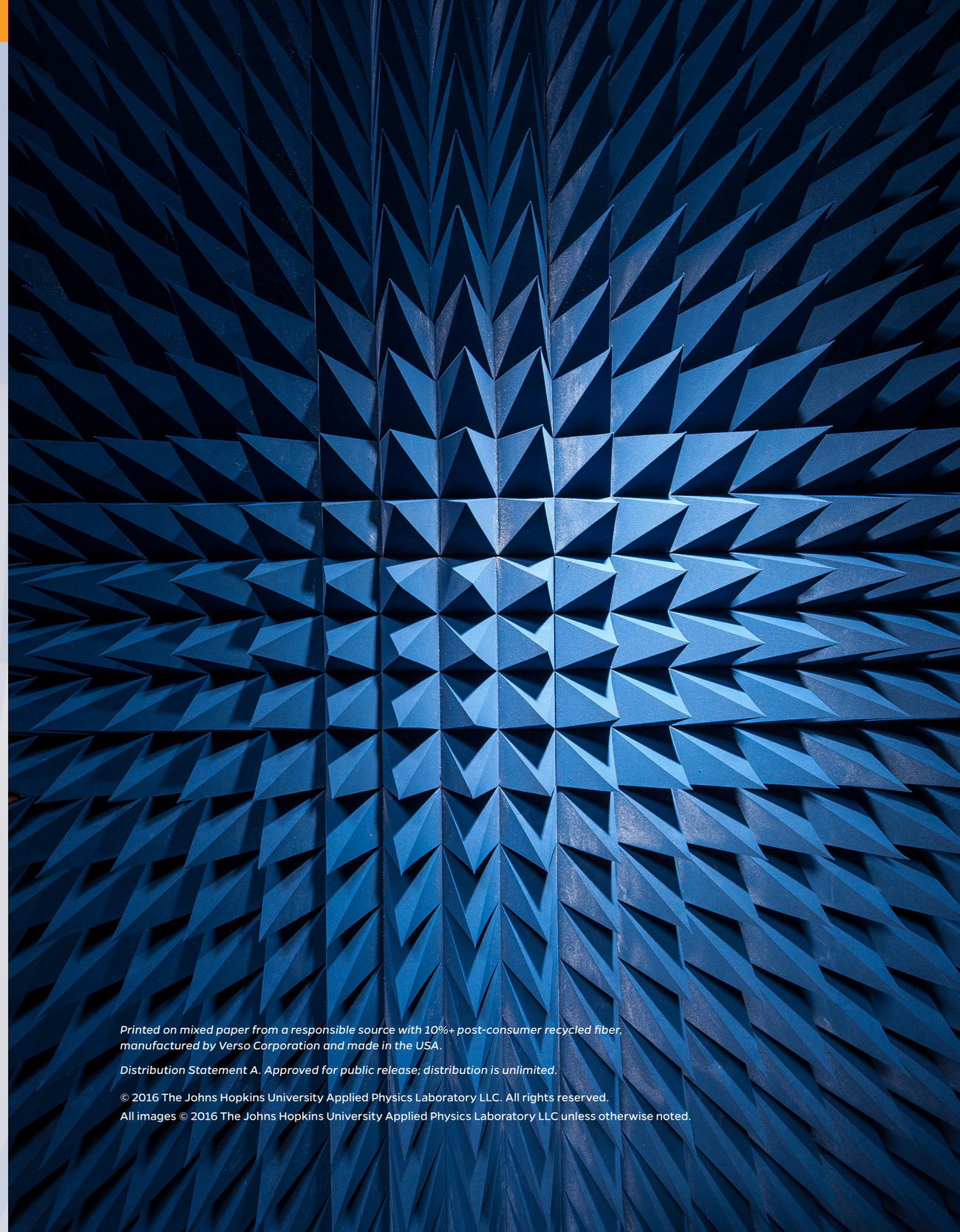

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Lexington Park, MD 20653

Los Angeles
400 Continental Blvd.
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The Johns Hopkins University Applied Physics Laboratory
11100 Johns Hopkins Road
Laurel, MD 20723-6099

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