

## TITLE II—RESEARCH, DEVELOPMENT, TEST, AND EVALUATION

### RESEARCH, DEVELOPMENT, TEST, AND EVALUATION, ARMY

#### Items of Special Interest

##### *3-D Printed Electronics Army Innovation*

The committee understands additive manufacturing (AM) is making innovative technological improvements that could yield major advances in Army indirect fire weapons' range and lethal effects. This technology can combine existing and new materials into 3-D printed circuit architectures producing smarter, lighter, and denser projectiles to double current ranges and achieve higher precision. The flexibility inherent in AM allows for ready incorporation of new materials into complex structural designs that cannot be produced by any other method. As the technology matures, AM can also be used in other Army priorities such as technology for new and lighter smart armor and other purposes.

The committee notes that the Army continues to invest in AM technology to rapidly design, prototype, and manufacture critical novel printed armaments components. The goal is to demonstrate the ability to print munitions completely on a single production line and assess this capability for potential implementation in an ammunition plant. This demonstration will also allow for an assessment of the potential to print replacement parts, customizable grenades, printed electronics and antennas. The committee supports the Army's investment in additive manufacturing technology and will continue to monitor its potential for industrial application as well as practical in-field use.

##### *Accelerated integration to counter emerging threats*

The committee supports the accelerated integration capability to counter emerging threats being initiated by the Program Executive Office, Missiles and Space. The Army is developing a government-owned capability to provide cyber-robust, networked new missile capabilities into the Army Integrated Air and Missile Defense systems designed to operate within rapidly evolving threat environments and timelines. The committee understands this is being accomplished through a unique approach to adapt and respond to real-time threats, dramatically accelerating the timeline to employ resilience in networked weapon systems. Therefore, the committee directs the Secretary of the Army to provide a briefing to the Committee on Armed Services of the House of Representatives by March 2, 2020, on the status of progress being made through this accelerated program.

##### *Advanced development of asset protection technologies*

The committee notes the Army's progress in developing advanced technologies for asset protection, such as Thermal Indicating Paints, Active Sensor Systems, Novel Power Solutions, Printed and Embedded Sensors for Army Weapons systems, Flexible Electronics, and others to support the warfighter. The committee directs the Secretary of the Army to provide a briefing to the committee not later than December 1, 2019 on the Army's plans and

programs, if any, to develop, demonstrate, manufacture and deploy advanced multi-functional materials and technologies that can be combined for customizable asset protection systems and increased weapon system capabilities.

*Advanced lightweight small arms and medium caliber ammunition*

The committee is encouraged by the Navy's progress on design, development and testing of advanced lightweight small arms and medium caliber ammunition. The committee directs the Secretary of the Navy to report to the committee by December 1, 2019 what efforts are underway to continue to explore and refine the use of advanced lightweight polymer cased ammunition technology to reduce the weight burden, enhance operational reliability, improve mobility and enhance survivability of the warfighter.

*Advanced materials and components*

The budget request contained \$35.1 million in PE 62144A for ground technology.

The committee is aware that research conducted under this program is developing materials and manufacturing processes that combine multiple classes of materials for innovative and pioneering use cases. As a result, advanced hybrid materials and novel manufacturing methods, including high entropy alloys, are being developed for critical programs including the Army's Long Range Precision Fires and Next Generation Combat Vehicles modernization efforts.

Therefore, the committee recommends an increase of \$5.0 million in PE 62144A for ground technology advanced materials and manufacturing research technology.

*Advanced technology for cold regions*

Over several years, the Department of Defense has identified the need to operate in the Arctic and other cold region environments is critical to our national security and homeland security interests. To realize a successful National Defense Strategy, a number of engineering challenges must be solved to evolve the Department's ability to construct, maintain, and retrofit horizontal and vertical infrastructure in cold regions. Once developed, these novel approaches to designing, building, and maintaining rapid, cost effective, small-footprint infrastructure will enable U.S. forces to better defend the homeland and exercise sovereignty by rapidly projecting capabilities to remote cold regions when needed. Therefore, the committee supports innovative construction materials for cold regions by further developing and testing initial prototypes of mapping systems and construction materials under austere conditions, and developing, calibrating, and verifying performance prediction models.

*Army unfunded requirement for munitions storage*

The committee recognizes the important work the Armaments Center, a science and technology reinvention laboratory at Picatinny Arsenal, plays in the ammunition life cycle to ensure our warfighters are appropriately equipped to complete their missions. The committee notes that the Under Secretary of Defense for Re-

search and Engineering's February 2019 Report to Congress on Unfunded Requirements for Laboratory Military Construction Projects included for this center an unfunded laboratory minor science and technology military construction project for an Igloo Storage Installation. The committee directs the Secretary of the Army to provide a briefing to the House Committee on Armed Services not later than November 30, 2019, on what the Army's plans are to ensure that the required construction and maintenance is implemented to support this mission.

*Briefing on secure communications with remote-piloted and unmanned ground vehicles*

The committee is aware that the Army is developing new ground combat vehicles that can be operated remotely or unmanned. At the same time, potential adversaries continue to develop capabilities that may compromise control of these remotely operated systems, as well as other components of the Army's communications networks.

The committee notes the Army is researching technologies that will protect and harden communication networks in contested environments, but is concerned about the integration of these systems relative to the maturity of remotely-piloted vehicles like the Optionally Manned Fighting Vehicle and the Robotic Combat Vehicle.

Therefore, the committee directs the Secretary of the Army to provide a briefing to the House Committee on Armed Services by September 30, 2019, on the Army's efforts to develop technologies that will protect control of remotely-piloted or unmanned vehicles, as well as other communications technologies, while operating in contested environments.

*Carbon fiber wheels and graphitic foam for Army vehicles*

The committee notes the evolution of the Army's testing and evaluation of Lightweight Metal Matrix Composite Technology as outlined in the report by the Assistant Secretary of the Army for Acquisition, Logistics, and Technology submitted to the congressional defense committees in accordance with the committee report accompanying the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (S. Rept. 115-262). The Army's report makes clear that its interest with respect to new materials for lightweight wheels and associated brake systems has transitioned to a more viable dual-use carbon fiber and graphite byproduct suitable for brake pads and liners throughout the tactical wheeled vehicle fleet.

The committee encourages the Army to continue to develop, prototype, and test affordable mesophase pitch carbon fiber and graphitic carbon foam components for the Next Generation Combat Vehicle and the tactical wheeled vehicle fleet to confirm their potential to reduce vehicle weight and improve fuel consumption and payload capacity over standard aluminum and steel designs. Accordingly, the committee directs the Assistant Secretary of the Army for Acquisition, Logistics, and Technology to provide a briefing to the House Committee on Armed Services not later than November 29, 2019, on the progress of the Army's development and testing efforts related to mesophase pitch carbon fiber and graphitic carbon foam vehicle components.

*Composite warhead technology*

The committee is aware of the Army's effort to facilitate rapid prototyping and demonstrations of composite ordinance packages consisting of composite warheads with multiple lethal effects payloads. The committee supports the Army's research and development efforts that study how composite and carbon-fiber warhead technologies are applicable to new hypersonic strike missiles. The committee encourages the Army to continue to explore the durability and weight benefits that composite warhead technology provides, thereby extending the range of the Army's long range precision fires.

*Defense Innovation and the Automotive Industry*

The committee commends universities and industry for their work in maturing technologies and producing materiel solutions to ensure our military maintains its technological edge. The commercial market driving the development of technologies is dynamic, and our military benefits greatly from the innovations that come from partnerships with small businesses and universities. As there are many lessons to be learned from independent research and the commercial market like the automotive industry, Science and Technology Reinvention Laboratories (STRs) carry out a significant portion of basic and developmental research in collaboration with academia and the private sector. Government-funded research efforts to address military threats are critical to reducing technology development risk. If successful, they can attract private sector partners that lead to manufacturing and commercialization or production of defense systems. The committee encourages the Department to work with industry, and in particular the automotive industry, to establish public/public and public/private (P4) Innovation Centers focused on the defense and automotive industries. The Innovation Centers could also serve as "learning labs" for Science, Technology, Engineering, and Math (STEM) based programs. The committee directs the Under Secretary of Defense for Research and Engineering and the Secretary of the Army, with support from the Director of the Defense Innovation Unit, by March 31, 2020 to provide a briefing to the armed services committees on how the Department is working with the automotive industry to identify innovative technologies and learn lessons applicable to the development and production of defense systems. The briefing should include discussion of any plans to establish Innovation Centers as described above, including in or around the Detroit Arsenal or the Ground Vehicle Support Center in Warren, MI.

*Expeditionary Maneuver Support Technologies*

The committee supports the development of Expeditionary Maneuver Support Technologies (EMST) for the next generation of command posts and supporting technologies, allowing combatant commanders to meet their increased operational requirements. This is necessary research for concealment, camouflage, deception, shielding, secure communications and other non-logistics based technologies above the individual soldier level, in order to support large scale maneuver operations. The committee encourages the Department to continue the development of advanced intelligent materials will be used as the pathfinder component for production

of these new EMST systems, provide a logistical cost savings to the Department of Defense, and enhanced protection for the units in the field.

*Expeditionary mobile base camp technology*

The committee understands that the Army has a need for rapidly deployable expeditionary structures that offer protection from battlefield threats. The committee therefore recommends that the Department of Defense examine:

- (1) next-generation rapidly deployable shelter systems which utilize thermoplastics-based design concepts;
- (2) the feasibility of 3-D printing shelter components using small and large scale printing technologies and bio-filled materials; and
- (3) applications for expeditionary smart materials including photovoltaics, smart textile materials, and thermoplastic multifilament and monofilament yarns.

*Foamable celluloid material*

The committee is aware that the Army has made investments and achieved progress in developing modern ammunition material and manufacturing technologies that have the potential to improve ammunition performance and reduce life-cycle costs. Given this progress, the committee encourages the Army to rapidly transition technologies when ready from development to production for operational use availability. For example, the committee understands there could be substantial performance improvement and cost savings derived from advanced technologies such as foamable celluloid combustible propellant cases for tank, artillery, and mortar ammunition. The committee, therefore, encourages the Army to complete the development and qualification of this new capability in order to make a timely production and fielding decision. Further, the committee directs the Assistant Secretary of the Army for Acquisition, Logistics, and Technology to provide a briefing to the House Committee on Armed Services not later than August 15, 2019, on plans for the continued development and potential for production and fielding of new ammunition technology, such as foamable celluloid combustible propellant cases, for tanks, artillery, and mortars.

*Future Vertical Lift*

The budget request included \$459.0 million in PE 63801A for Future Vertical Lift (FVL) platform research and development. Of this amount, \$427.0 million was requested for development of the Future Attack Reconnaissance Aircraft (FARA), a new scout helicopter, while \$30.2 million was requested for the Future Long-Range Assault Aircraft (FLRAA), the planned replacement for the UH-60 Black Hawk helicopter.

Future Vertical Lift (FVL) is the Army's initiative to develop and field next-generation rotary wing aviation technologies and platforms through rapid prototyping and streamlined acquisition processes. The committee supports FVL's near-term goals and objectives of developing modern capabilities to replace the OH-58 Kiowa scout reconnaissance helicopter and the UH-60 Black Hawk utility helicopter.

The committee understands the Army awarded five Other Transaction Authority contracts in April 2019 for FARA prototypes and intends to down-select to two competitors in March 2020. However, the Army failed to include funds to bridge the gap between the Joint Multi-Role Technology Demonstration (JMR-TD) for transformational vertical lift capabilities and the planned start of the Future Long-Range Assault Aircraft. Instead, the Army included \$75.0 million in its unfunded priority list to accelerate FLRAA through an extension of the JMR-TD program. The committee believes additional details are required in order to make an informed evaluation of the Army's near and long term objectives for the Army aviation enterprise. The committee expects the aviation modernization strategy required elsewhere in this Act to help clarify these questions.

*Heavy Equipment Transporter System trailer development*

The committee encourages the Army to continue development and procurement of a Heavy Equipment Transporter (HET) trailer solution for current and future combat vehicles. The committee notes that the Army's current trailer is rated for 70 tons, but modernized M1A2 Abrams Main Battle Tanks will weigh in excess of 80 tons. Given the gross vehicle weight limitations on current trailer systems, the committee is concerned that these trailers cannot transport the most modern version of the Abrams tank. The committee believes the Army requires a new, more capable trailer and therefore encourages the Army immediately to begin to plan, program, and fund the accelerated modification of fielded HET trailers. The committee directs the Secretary of the Army to provide a briefing to the House Committee on Armed Services by November 1, 2019, that details courses of action to accelerate needed modernization of current HET trailers.

*HEROES program*

The budget request contained \$115.2 million in PE 62143A for Soldier Lethality Technology.

The committee is aware of the work being done by the U.S. Army's Combat Capabilities Development Command (CCDC) Soldier Center in improving the protection, survivability, mobility, and combat effectiveness of the Army. The committee is also aware that the Harnessing Emerging Research Opportunities to Empower Soldiers (HEROES) program is an ongoing joint research and development initiative involving both academia and industry that accelerates research and innovation through integration of intellectual assets and research facilities. The committee believes programs like HEROES provide benefit to research in areas of advanced ballistic polymers for body armor, fibers to make uniforms more fire resistant, and lightweight structures for advanced shelters that provide tangible benefits to the warfighter. To ensure the Army remains at the cutting edge of technology in these critical areas, the committee recommends an increase of \$5.0 million in PE 62143A for the HEROES program.

*High performance advanced polymers*

The committee is aware of Army work being done to improve the protection, survivability, mobility, and combat effectiveness of its

vehicles, specifically in extreme temperatures. The committee is also aware of the efforts to develop advanced polymers for ground vehicles including the Stryker, Joint Light Tactical Vehicle, and the medium tactical vehicles. The committee believes additional research in advanced ballistic polymers that improves upon current resin systems to: maintain ballistic performance in hot and humid environments; keep fibers in uniforms more fire resistant; and create lightweight structures for advanced shelters all provides tangible benefits to the warfighter. Therefore, the committee encourages the Army to continue its support of such programs.

#### *Humanitarian de-mining research and development*

The budget request contained \$10.8 million in PE 63920D8Z for humanitarian de-mining research and development.

The committee supports the humanitarian de-mining research and development program overseen by the Deputy Assistant Secretary for Stability and Humanitarian Affairs. This program develops and tests systems to detect and clear landmines, unexploded ordnance, and improvised explosives devices. The committee understands this research and development improves technology used by the military, informs military equipment procurement decisions, and supports stabilization and humanitarian projects funded by the Department of State while also fostering a collaborative relationship with host nation governments. The committee is aware of the value of this program.

Therefore, the committee recommends \$15.8 million, an increase of \$5.0 million, in PE 63920D8Z for humanitarian de-mining research and development.

#### *Improved Turbine Engine Program*

The budget request included \$206.4 million in PE 67139A for the Improved Turbine Engine Program (ITEP)

The committee continues to support development of the Army's Improved Turbine Engine Program. ITEP was initiated as a competitive development and acquisition program to provide a more fuel efficient and powerful helicopter engine enhancing the performance and operational readiness of the Army's UH-60 Black Hawk and AH-64 Apache fleets. The committee has supported significant Army investments into competitive technology development programs for turbine engines over the past decade and is encouraged by the significant progress the Army has made in maturing technologies that would lower ITEP programmatic risks. The committee also notes that ITEP will benefit the Army's future vertical lift development efforts, in particular, the Future Attack Reconnaissance Aircraft (FARA) program.

The committee understands that the engineering and manufacturing development phase of ITEP is fully funded through fiscal year 2024 and that maintaining schedule to meet both the current and future platform integration timelines is crucial to the Army's aviation modernization enterprise. The committee expects the Army to maintain the current ITEP schedule as any delays will affect the planned delivery of new capability and Army aviation future readiness.

The committee recommends \$206.4 million, the full amount requested, in PE 67139A for ITEP.

*Improvement of combat helmet suspension systems*

The budget request contained \$118.5 million in PE 63118A for Soldier Lethality Advanced Technology, including \$14.8 million for body armor and integrated head borne advanced technology projects.

The committee supports continued efforts to improve the performance of personal protective capabilities to increase warfighter performance and safety. The committee understands that recent technology development in helmet pad suspension systems, like microlattice technology, may result in next-generation helmet suspension systems capable of absorbing impacts more effectively while maintaining user comfort and sustaining performance requirements.

Therefore, the committee recommends an increase of \$5.0 million in PE 63118A for body armor and integrated head borne advanced technology projects to improve helmet suspension pad systems using microlattice technology.

*Instrumentable Multiple Integrated Laser Engagement System*

The committee is aware of the important role that the Instrumentable Multiple Integrated Laser Engagement System has in training Army and Marine Corps elements on force-on-force training at the National Training Center and other training centers worldwide. The committee is also aware of the criticality of this training to force readiness levels, particularly as the military services pivot towards peer adversaries. The committee supports the Army's efforts to develop innovative technologies, such as the Synthetic Training Environment program, and is interested in the Army's plan to continue to improve the Instrumentable Multiple Integrated Laser Engagement System through the relevancy program and serve as a bridge to future virtual training solutions. Therefore, the committee encourages the Army to continue to support the Instrumentable Multiple Integrated Laser Engagement Relevancy Program as a cost-effective and capable bridge to future virtual training solutions.

*Modeling and Simulation for Ground Vehicle Development*

The committee notes that modeling and simulation (M&S) has demonstrated its utility as a tool for vehicle technology development by providing program managers with necessary information related to reliability and performance challenges in advance of making significant investment decisions for future development. The committee also notes that M&S is particularly relevant in the development of unmanned vehicle systems that could use artificial intelligence. As the Army continues to modernize its ground combat and tactical vehicle systems, the committee encourages maximization of M&S to realize potential savings in experimentation and prototyping, predict and control program costs and, where possible, accelerate the speed of development and fielding of new ground vehicle capabilities. Therefore, the committee directs the Assistant Secretary of the Army for Acquisition, Logistics, and Technology to provide a briefing to the House Committee on Armed Services no later than December 1, 2019 on how M&S is being incorporated into the development of next generation combat vehicles to include the Optionally-Manned Fighting Vehicle and Robotic Combat Vehi-

cle programs, as well as identify any barriers and challenges that may exist regarding the full utilization of M&S for ground combat and tactical vehicle development.

*Modern mobile sheltering systems*

The committee encourages the Department of the Army to explore the utilization of modern sheltering systems. Investment in rapidly deployable, hard-walled systems with integrated technologies and the use of modern and modular materials could advance the development of a modernized shelter that meets current and future operational requirements. Additionally, investment in new technologies for sheltering systems that are agile, durable, modular, customizable, and scalable could create new opportunities for shelter systems suitable not only for multi-domain combat operations, but also easily adaptable for use in disaster response and humanitarian relief operations.

*Multi-mission Medium Range Railgun Weapon System and Integrated Power and Thermal Management System*

The committee recognizes progress made by the Army to mature the multi-mission medium range railgun weapon system (MMRRWS) and the Integrated Power and Thermal Management System (IPTMS). The committee understands that MMRRWS, if successful, would support integrated air missile defense, mobile short-range air defense, and indirect and direct fires applications. This capability would launch a guided projectile significantly farther and with more lethality than traditional systems, and will address critical gaps in U.S. air defense against growing threats from peer and near-peer competitors. The committee further understands IPTMS was developed specifically to support the Army's Maneuver-Short Range Air Defense (M-SHORAD) requirement. Adopting IPTMS could potentially accelerate development of a directed energy capable M-SHORAD capability as early as 2021. The committee encourages the Army to continue to leverage internal investments in developing MMRRWS and IPTMS in order to fully evaluate the potential of railgun technology on mobile platforms.

Therefore, the committee directs the Secretary of the Army to provide a briefing to the House Committee on Armed Services not later than February 1, 2020, on the current capability of MMRRWS and IPTMS, ongoing development and technology maturation of these systems, the results of any technology demonstrations of these capabilities, and the integration of MMRRWS and IPTMS and their components with existing or planned M-SHORAD systems.

*Multi-spectral thermal mitigation technologies*

The budget request contained \$118.5 million in PE 63118A for soldier lethality advanced technologies.

The committee is aware that the military services have established baseline standards for flame resistant uniforms that provide near-infrared thermal sensor protection for service members who are deployed in hostile areas. The committee understands that recent technical developments in sensor technologies and sensor mitigation are advancing at a pace well ahead of the current research, development, and procurement efforts. As a result, long-range detection and identification of our service members from hostile near-

peer as well non-state actors is an emerging force protection threat. As such, the committee encourages the military services to explore multi-spectral sensor mitigation technologies, and to incorporate them into current and future uniform requirements and testing in use by the armed services.

Therefore, the committee directs the Secretary of the Army, in coordination with the Secretaries of the Navy and the Air Force, to provide a briefing to the House Committee on Armed Services by March 1, 2020, on the infra-red protection of current uniform standards against emerging sensor technologies, including an analysis of the feasibility, availability, and cost of material solutions that could mitigate these emerging thermal sensor technologies.

Further, the committee recommends an increase of \$5.0 million in PE 63118A for soldier lethality advanced technologies.

*National Academies review of technologies related to Army Strategic Long-Range Cannon*

The committee notes that modernization of long-range precision fires is the Army's highest priority for meeting the requirements of the National Defense Strategy and the operational challenges associated with peer and near-peer potential adversaries. One of the technologies the Army is pursuing is a Strategic Long-Range Cannon capable of firing a projectile at hypersonic speed up to 1,000 miles. The committee is interested to learn more about this imaginative concept and the technical challenges associated with development of such a capability especially with respect to propellant, projectiles, and cannon. Accordingly, the committee directs the Secretary of the Army to enter into an arrangement with the Board on Army Research and Development of the National Academies of Sciences, Engineering, and Medicine to conduct a study that identifies and evaluates the technology approaches, policies, and concepts of operations of the Strategic Long-Range Cannon (SLRC) program. The study shall include:

(1) an identification and evaluation of attributes of potential peer or near-peer adversaries operating environments and concepts that would enhance or reduce the effectiveness of SLRC;

(2) an identification and evaluation of limitations and vulnerabilities of current ground-based capabilities for long-range fires as well as existing and proposed countermeasures;

(3) an identification and evaluation of key and essential technologies needed to achieve documented goals and capabilities of SLRC along with associated technologies required to support manufacturability and sustainability; and

(4) provide a technology maturation roadmap, including an estimated funding profile over time, needed to achieve an effective operational SLRC that describes both the critical and associated supporting technologies, systems integration, prototyping and experimentation, and test and evaluation.

The Secretary shall submit the study to the congressional defense committees not later than August 31, 2020. The study submitted shall be classified at levels appropriate to and sufficient for access to data necessary for a comprehensive review of the subject and related technologies but must include an unclassified summary of findings and recommendations. The Secretary may submit com-

ments, if any, to accompany the study's classified or unclassified findings and recommendations.

*Real time transmission of weapons usage data*

The committee recognizes the importance of the Next Generation Squad Weapon program and notes the potential of new technology involving smart weapons capable of real time transmission of weapons usage data. The committee directs the Assistant Secretary of the Army for Acquisition to provide a briefing to the House Committee on Armed Services no later than November 1, 2019 on the utility of real time transmission of squad level weapons usage data for training and combat operations, logistics, and maintenance, to include potential or existing technology.

*Women in Army science, technology, engineering, and mathematics careers*

The committee is aware of the important role the Picatinny Science, Technology, Engineering and Mathematics (STEM) Education Office has in providing assistance to schools, support for students and leadership in developing activities to insure preparedness through education. As part of a continuing effort to encourage young women to pursue technical careers, in 2019 Picatinny Arsenal hosted its sixth year of "Introduce a Girl to Engineering," which attracted 100 students from 28 schools. Women comprise only 16 percent of the scientists and engineering workforce of the Combat Capabilities Development Command. Therefore, the committee encourages the Army to continue efforts to promote STEM education at Army labs and urges the Secretary of the Army to further utilize the Manufacturing Engineering Education program to promote women in STEM Army careers with awards under the selection criteria provided by section 2196 (g)8 of title 10, United States Code.

The committee encourages the Secretary to use the Department of Defense's Science, Mathematics, and Research for Transformation Program to further encourage women to enter the Army's science and engineering workforce.

RESEARCH, DEVELOPMENT, TEST, AND EVALUATION, NAVY

Items of Special Interest

*Academic partnerships for undersea vehicle research*

The budget request contained \$57.1 million in PE 62747N for undersea warfare applied research. The committee encourages the Department of the Navy to focus investments in research projects that are relevant to specific engineering and manufacturing needs, as well as defined systems capabilities. The committee also supports partnerships with industry and academia that are focused on well-defined short- and long-term submarine and autonomous undersea vehicle research needs, accelerated technology transition, and strong workforce development to develop a healthy industrial base with capacity needed to develop and build the Navy's next generation of advanced nuclear submarines and other undersea vehicles and systems. Therefore, the committee recommends an in-

crease of \$10.0 million in PE 62747N for innovative research and manufacturing partnerships between academia and industry.

*Advanced Manufacturing of Critical Scale Materials*

To ensure the next generation of submarines incorporates the most cutting edge technologies, the Navy must advance the qualification and certification of Advanced Manufacturing (AM) processes, materials, and components to allow the Navy to integrate AM capabilities into current and future systems and platforms. The committee directs the Secretary of the Navy to report to the committee by December 1, 2019 on what efforts are underway to integrate AM. Further, as part of this report, the committee directs the Navy to include specific information about the testing and qualification of processes, materials, and components required to meet Columbia Class requirements and milestones.

*Advanced precision materials research*

The committee is aware that research conducted under this program is developing critical components and combining multiple classes of materials for innovative and pioneering use cases, including the use of metal powders and substrates for military specifications. As a result, advanced hybrid materials and novel manufacturing methods, including wire-arc manufacturing and lightweight materials are being developed for critical programs including the Navy's Cross Platform System Development Program.

*Advanced radar research*

The committee notes there have been major advances in the field of radar development with respect to phased array radar technology in a digital design. The development of this technology is a critical enabler for the Navy in the development of tools to increase target detection as well as improve electronic warfare and adaptive sensing capabilities. The committee directs the Chief of Naval Research to submit a report to the House Committee on Armed Services not later than April 30, 2020, on its support of partnerships with laboratory-based antenna test facilities that help the Navy understand, characterize, and calibrate advanced all-digital radars that are under development.

*Autonomous vehicle collaboration across maritime domains*

The budget request contained \$119.5 million in PE 62123N for applied research into autonomous vehicle collaboration across maritime domains.

The committee supports the Navy's investment in unmanned systems, such as autonomous underwater and surface vehicles. While autonomous systems are part of a strategy to maintain military technological advantage, there are lingering gaps in the performance of maritime autonomous vehicles intended to serve key Navy missions.

Therefore, the committee recommends an increase of \$10.0 million in PE 62123N for applied research into autonomous vehicle collaboration across maritime domains, particularly for rapid prototyping and experimentation enabling coordination between unmanned underwater and surface vehicles.

*Critical bandwidth gaps for Navy deployments*

The committee recognizes that the Department of Defense requires the capability to utilize in real time the massive amount of data compiled from technically advanced weapons systems. Current limitations in bandwidth and geographically challenging environments hinder the Department's ability to securely share in real time large volumes of data between warfighting units at the network's edge and command-and-control facilities. Nowhere is this problem more acute than for naval ships operating at sea. To address one specific gap, the Navy has established the Maritime Dynamic Over the Horizon Targeting System (MDOTS). MDOTS will utilize advanced commercially integrated technologies to generate a secure high-bandwidth network for a new over-the-horizon weapons system. The Navy has plans to test this system in 2019 and the committee is aware that other programs in the Department could also benefit from this capability.

One other example of a critical gap is in operational support to the F-35 Joint Strike Fighter. The F-35 generates massive amounts of data that must be shared in real-time with the pilot and command-and-control facilities to maximize effectiveness, intelligence, and readiness. The Navy's communications infrastructure currently lacks the high-bandwidth capabilities to enable the sharing of this volume of data.

Therefore, the committee directs the Assistant Secretary of the Navy for Research, Development, and Acquisition to explore the potential for using the MDOTS for a pilot project to establish a high-bandwidth networking capability to support Dynamic Over the Horizon Targeting at sea and on land. In addition, the committee directs the Assistant Secretary to review the Navy's existing networking capabilities, and identify critical gaps in support for deployments across the Navy and Marine Corps portfolio of programs. The committee further directs the Assistant Secretary to provide a briefing to the House Committee on Armed Services by March 1, 2020, that identifies priority gaps to be addressed.

*Defense University Research Initiatives*

The budget request contained \$116.8 million in PE 601103N for University Research Initiatives.

Through a competitive grant process managed by the Office of Naval Research, the Defense University Research Instrumentation Program (DURIP) funds the purchase and development of research equipment and infrastructure by academic institutions necessary for high-quality Navy relevant science. This instrumentation plays a vital role in allowing defense-critical research projects to acquire needed technical resources specifically engineered to meet their requirements and is critical in accelerating the development of operational capabilities for the warfighter. The technologies developed and acquired through the DURIP process ensure that the next generation of scientists and engineers are trained with cutting-edge capabilities for the military National Security Innovation Base workforce.

Therefore, the committee recommends an increase of \$5.0 million in PE 601103N to support the Navy's cutting-edge DURIP research.

*Energy resilience*

The budget request contained \$119.5 million in PE 62123N for Force Protection Applied Research.

The committee recognizes the need for additional research to assist the Navy in its efforts to create a more robust energy infrastructure. To achieve military energy resiliency, these challenges can be best met by leveraging experienced energy university researchers working in concert with industry partners and the Navy. Specific areas of interest include: addressing electrical power intermittency, integrating renewable energy sources into the grid, energy storage, improved micro-grids, grid security, local generation of zero-carbon fuels, and the inspection and structural health monitoring of critical energy infrastructure.

The committee recommends an increase of \$5.0 million in PE 62123N for energy resilience applied research.

*Enterotoxigenic Escherichia Coli research*

Enterotoxigenic *Escherichia coli* (ETEC) is one of the most prevalent pathogens responsible for diarrheal disease. Among U.S. warfighters deployed in the Middle East, ETEC has been the leading pathogen contributing to bacterial diarrhea. The Naval Medical Research Center (NMRC) Infectious Diseases Directorate (IDD) has established an Enteric Diseases Department to develop effective countermeasures to prevent or abate bacterial diarrhea. Infectious diarrhea historically has been a substantial cause of morbidity for deployed U.S. warfighters and continues to impact those currently serving overseas in the global war on terror. Similar pathogens also are responsible for travelers' diarrhea in civilian populations and endemic diarrheal diseases in young children in resource limited regions around the world. According to NMRC, acute infections often resolve on their own in 3 to 5 days but half of the service members infected report a decrease in job performance and 1-in-10 will go on to develop post-infectious irritable bowel syndrome. The Navy, Defense Advanced Research Projects Agency and academia have been working together to develop a platform for the delivery of immune molecules, mostly antibodies, which are safe and effective in rapidly establishing immune protection from ETEC diarrhea.

The committee supports continued preclinical studies needed to facilitate an Investigational New Drug (IND) submission, to include:

- (1) process Development (formulation, stability) and Quality (assay development) studies;
- (2) manufacture of preclinical materials sufficient for all IND-enabling pharmacology, toxicology and efficacy tests;
- (3) IND-enabling safety studies including pharmacology and toxicology;
- (4) IND-enabling animal efficacy studies to determine optimum dose and robustness of response; and
- (5) development of protocols in preparation of First-in-Human studies.

*Hearing loss and prevention treatment*

The budget request contained \$63.8 million in PE 62236N for Warfighter Sustainment Applied Research, which includes funding

to address noise induced hearing loss. The committee recognizes members of the Armed Forces often experience hearing loss at higher rates and that tinnitus is one of the most prominent disabilities amongst veterans. Therefore, the committee recommends \$63.8 million, the amount requested, in PE 62236N for Warfighter Sustainment Applied Research and urges the Department of the Navy to develop hearing loss drug therapies and related clinical applications.

*High Energy Laser system integration*

The committee is encouraged by the Navy's rapid demonstration of Laser Weapon Systems (LaWSs) on surface ships. In a short period of time, the Navy has deployed the 30 kilowatts (kW) LaWS on the USS Ponce (Afloat Forward Staging Base (Interim)-15) followed by the 150 kW Laser Weapon System Demonstrator (LWSD) on the USS Portland (Landing Platform/Dock-27) in 2019. The improvements in power and beam quality make this a near 100 fold improvement in lethality. The committee is also encouraged by the 60 kW HELIOS program for integration on Destroyer Designated Guided ships by 2020. However, there appears to be more opportunity to integrate High Energy Laser (HEL) systems on large capital ships including aircraft carrier, fixed wing, nuclear powered (CVNs) and large amphibious ships to increase defensive capability and lethality of our expeditionary forces as evidenced by the deployment of LWSD on the USS Portland. The committee directs the Secretary of the Navy to submit a report to the congressional defense committees not later than April 1, 2020, describing a path forward for integration of HEL Systems 150–300 kW on large capital warships, including CVNs and large amphibious ships.

*Navigation channel clearance for nuclear powered ballistic missile submarines*

The committee recognizes that 70 percent of the United States nuclear deterrent is committed to ballistic missile submarines (SSBNs) concentrated at just two Navy bases in Bangor, Washington, and Kings Bay, Georgia. Each time an SSBN departs or returns to its respective home port, it must travel through shallow, restricted waterways that are open to commercial and private traffic. The committee is aware that U.S. Strategic Command has a requirement to survey these waterways in order to monitor for threats and obstructions which could damage transiting submarines and is interested in steps being taken by the Navy to meet this requirement to protect critical strategic assets.

Therefore, the committee directs the Secretary of the Navy to submit a report to the congressional defense committees by October 1, 2019, on measures instituted to ensure the safety and security of ballistic missile nuclear submarines operating in the approaches to Navy bases in Bangor, Washington, and Kings Bay, Georgia. The report should include:

(1) security measures mandated by the Department of Defense related to the operation of ballistic missile submarines entering and leaving the ports of Bangor, Washington, and Kings Bay, Georgia;

(2) current operational posture and capabilities employed to meet the mandated security requirements and any requirements not currently met; and

(3) specific measures to ensure the navigation channels for these ports are free of obstructions and other threats to transiting ballistic missile submarines.

*Office of Naval Research Manufacturing Technology Program*

The budget request contained \$60.1 million in PE 63680N for the Navy's Manufacturing Technology (ManTech) program.

The Office of Naval Research's (ONR) ManTech program supports the productivity and responsiveness of the U.S. Defense Industrial Base by funding development, optimization, and transition of enabling manufacturing technologies to key naval suppliers. Submarine and undersea vehicle industries are a key part of this industrial base. The contribution of subsurface vehicles to continued undersea dominance are measured in decades of service life and are based on the creation and implementation of near- and long-term technological advances. However, global access to technology, accelerated rate of technology development, and implementation and budget constraints threaten to undermine our dominance in this crucial area.

ManTech fosters partnerships between academia, industry, and government research and development communities in support of undersea vehicles and technologies, with the goal of creating and rapidly transitioning innovative technologies and specially trained personnel to enable continued U.S. dominance in undersea warfare and weapon systems.

Therefore, the committee recommends an increase of \$20.0 million in PE 63680N for ONR's ManTech program to enhance joint private and academic partnerships and performance and reduce costs of the shipbuilding process while ensuring that advanced technologies are incorporated into the next-generation of undersea vehicles.

*Warfighter safety and performance*

The budget request contained \$63.8 million in PE 62236N for Warfighting Sustainment Applied Research.

The committee is aware that this program funds critical technology efforts to improve warfighter safety and enhance individual performance under adverse conditions. The program also funds ongoing research efforts to prevent occupational injury in hazardous, deployed environments, including studies on decompression sickness, oxygen toxicity, optimization of diver performance, and assessment of the impact of thermal stress on operational performance. The committee encourages the Navy to continue studies and research into new technologies that improve care for sailors in extreme environments and mitigate the effects of undersea stresses on human safety, performance, and resilience.

Therefore, the committee recommends \$68.8 million, an increase of \$5.0 million, in PE 62236N for warfighter safety and performance.

## RESEARCH, DEVELOPMENT, TEST, AND EVALUATION, AIR FORCE

## Items of Special Interest

*Advanced composites for large structures*

The committee is aware of the current constraints on large-scale space and hypersonic vehicle fabrication, material process equipment, and composites. The committee is also aware of the demand for new epoxy resins and composite materials that can expand the process envelope for aerospace composite structures and operate in extreme temperatures, including space environments. Developing advanced, on-demand composite fabrics can reduce material waste, shorten production lead times, and provide additional manufacturing flexibility for large vehicle sections. The committee believes additional research is needed on epoxy and composite fabric formulas and equipment to understand the material properties and effects to meet space and hypersonic vehicle system requirements.

*Aerospace Career Training Expansion Report*

The committee recognizes the important role depots provide in achieving the Air Force's mission to fly, fight and win in air, space and cyberspace, and believes in the value of ensuring that the depot feeder communities have strong science, technology, engineering, and math (STEM) educational and workforce development opportunities. Critical investments in workforce are necessary to be better prepared to meet the future needs of the aerospace and defense industry sector. Diverse aerospace training programs and stackable credentials can also provide a clear sequenced pathway to ensure success and goal-oriented outcomes.

Therefore, the committee directs the Under Secretary of Defense for Research and Engineering and the Under Secretary of Defense for Acquisition and Sustainment, with support from the Assistant Secretary of the Air Force for Acquisition, Technology and Logistics, to provide a report to the congressional defense committees not later than February 28, 2020 on the Department's innovation, acquisition, and STEM programs that could be extended to the communities supporting Air Force depots. The report should include, but not be limited to, programs such as: Hacking4Defense within the National Security Innovation Network; the program on enhancement of preparation of dependents of members of armed forces for careers in science, technology, engineering, and mathematics as laid out in Chapter 111 of title 10 United States Code; small business programs such as Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) as defined under section 9 of the Small Business Act (15 U.S.C. 638); university research programs; public/public and public/private programs under the authority of the Air Force Research Laboratory; and Defense Acquisition University virtual or regional campuses.

*Aerospace Composites Manufacturing*

The budget request contained \$43.1 million in PE 63680F for the Manufacturing Technology Program, including funds to initiate the program on Transforming Aerospace Composites Manufacturing.

Transforming Aerospace Composites Manufacturing enables key cost reductions, low cost tooling, and agile rapid response require-

ments identified as a critical need for new unmanned aerial systems and other future vehicles without sacrificing high performance requirements. The committee believes this investment is critical for maintaining the United States' technological edge by allowing for rapid innovation and reduced lead time as well as reduced procurement cost of these high performance systems.

Therefore, the committee recommends \$53.1 million, an increase of \$10.0 million, in PE 63680F for cost reduction for aerospace composite structures.

*Briefing on Surface to Air Electronic Warfare Threats*

The committee recognizes that advanced enemy threat systems continue to evolve and modernize and as a result could be immune to current U.S. defensive systems, including Air Force electronic warfare (EW) jamming systems. The committee further recognizes that existing radar guided surface-to-air systems can detect and identify legacy jamming signals, which could significantly increase U.S. military aircraft vulnerabilities for deployed military air crews. Therefore, the committee directs the Secretary of the Air Force to conduct an advisability and feasibility analysis of developing open standards compliant advanced threat system exploitation techniques that could rapidly defeat advanced threat systems within an open system framework. The committee believes this technology could provide increased protection to U.S. military aircraft, resulting in increased mission effectiveness and air crew survivability. The committee further directs the Secretary of the Air Force to provide a briefing to the House Committee on Armed Services by February 1, 2020 on the results of this analysis, as well as update the committee on current actions being taken to improve current EW jamming systems.

*Digital twinning*

The committee notes that “digital twin” technology has the ability to combine numerous technologies within a weapon system, such as the F-35 Joint Strike Fighter, to create a full-scale digital replica of the original weapon system. This digital replica could assist the Department of Defense in conducting predictive analyses to determine and more fully comprehend performance, reliability, and maintenance requirements before issues impact a weapon system's performance during development and manufacturing, or after the system is fielded.

Therefore, the committee directs the Secretary of Defense to provide a briefing to the House Committee on Armed Services not later than March 1, 2020, that explains how the F-35 program is implementing the use of digital twinning technology across the F-35 system enterprise.

*Distributed Common Ground System and 10 U.S.C. 2377*

The committee notes the significant progress that the Army has made in deploying the distributed common ground system of the Army. The transition to “Capability Drops” and the increased use of readily available technology integration have improved program outcomes and accelerated deployment timelines.

The committee encourages the other military services and agencies of the Department of Defense to review the Army's approach

to determine whether that approach would improve outcomes for their own distributed common ground system programs. In particular, the committee urges program managers for the other distributed common ground system programs to learn more about the Army's approach to the requirements of 10 U.S.C. 2377 and directs the Secretary of the Air Force to brief the committee on the acquisition strategy for the distributed common ground system of the Air Force, with particular attention to the process used to determine whether commercial technologies can meet requirements pursuant to 10 U.S.C. 2377, not later than September 30, 2019.

*Educational partnership agreements for aerospace propulsion*

The budget request contained \$198.8 million in PE 62203F for aerospace propulsion research and development.

The committee recognizes that confronting emerging threats to vital U.S. assets in space is critical to the national security of the United States. The committee further understands the U.S. Air Force is pursuing advanced science and technology research to maintain secure operations to and in space and that effort will require additional rocket and space focused engineers over the next decade.

The committee commends the Air Force for its ongoing effort to accelerate its strategic capabilities in space operations through next generation access to space and maneuverability through the use of Educational Partnership Agreements (EPAs) (10 U.S.C. 2194). The committee supports the use of EPAs, which are a vital resource that provides authorized funding directed to academic institutions to stimulate growth in science, technology, engineering and mathematics education. EPAs play a critical role in encouraging and enhancing study in scientific disciplines at all levels of education and in generating future generations of scientists and engineers within the United States.

Therefore, the committee recommends an increase of \$10.0 million in PE 62203F to accelerate Educational Partnership Agreements that advance the mission of the Air Force Research Laboratory to pioneer transformative aerospace technologies and accelerate its long-term strategic objectives in key areas such as energy security, energy optimization, reusability, maneuverability, and multi-mission mobility.

*Kessel Run Commercial Outreach*

The committee notes the Air Force's continued use of agile development methods in the Kessel Run program. The committee encourages continued commercial outreach and commercial market research by the Kessel Run program in order to ensure that innovative commercial solutions are available to meet Air Force needs, while focusing on national security-unique challenges with in-house development teams.

The committee directs the Air Force to provide a briefing on Kessel Run plans not later than September 1, 2019. Such a briefing should include:

- (1) an update on current priorities for Kessel Run;
- (2) measures to ensure compliance with section 2377 of title 10, United States code, section 855 of the National Defense Authorization Act for Fiscal Year 2016 (Pub. L. 114–92, 129 Stat. 919), and

other attempts to ensure the use of innovative commercial technologies;

(3) plans to transition Kessel Run technologies into established programs of record.

*Light attack and armed reconnaissance experimentation*

The budget request contained \$35.0 million in PE27100F for continuation of Light-Attack Armed Reconnaissance (LAAR) experimentation.

The committee notes that the Air Force plans to apply \$100.0 million in fiscal year 2018 appropriated funding, and plans to request reprogramming authority to realign \$25.0 million in fiscal year 2019 appropriated funding, to purchase six test article LAAR platforms (three AT-6 and three A-29 aircraft) to continue Phase 3 experimentation activities.

The committee notes that the Air Force is not ready to make a decision on a potential procurement for LAAR without completing additional analyses on all potential solutions in order to find a solution that fits tactical, operational, and strategic requirements for a wide variety of allies and partners. The Air Force determined after the conclusion of Phase 2 experimentation that the results gained thus far have not provided enough information, nor has the LAAR experiment strategy explored other platforms that could fill lesser contingency and international partner mission requirements. The committee further notes that the Air Force believes continued experimentation during Phase 3 will allow for additional consideration of current and emerging unmanned, rotorcraft, and turbojet technologies to assess cost-effectiveness and capability sufficiency to ensure that a future LAAR platform or platforms will maximize meeting a diverse set of mission requirements and capability gaps. The committee appreciates the deliberate and methodical approach the Secretary of the Air Force is taking through experimentation and data analysis to fully inform a future procurement decision for LAAR capabilities and this new mission area. However, prior to entering Phase 3 experimentation activities, the committee expects the Secretary to establish and document the Phase 3 experimentation strategy, design, goals, objectives, and metrics. The committee also expects the Secretary to consult with the Commander, Special Operations Command to assess how both general purpose forces and special operations forces can leverage experimentation activities. The committee directs the Secretary of the Air Force to provide a briefing to the House Committee on Armed Services not later than September 1, 2019, on the scope and plans for Phase 3 experimentation.

*Low-cost attritable aircraft technology*

The committee supports the intent of the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics to accelerate the Air Force Research Laboratory's Low-Cost Attritable Aircraft Technology (LCAAT) program for collaborative pairing with manned platforms, potentially including the 35. The committee views the combined application of commercial technology, autonomy, and artificial intelligence as imperative for solving current military challenges. Teams of low-cost collaborative systems provide new mechanisms to ensure survivability and mission success

without leveraging exquisite technology and the associated high cost and long development timelines.

Integration and technology demonstrations reduce the risk and time required to transition technologies into operational systems. Accordingly, further prototyping and technology enhancements are necessary to transition the LCAAT demonstrator aircraft system into a fully operational capability. Continued testing and the development and integration of technology is required to provide a runway takeoff capability; airborne weapons deployment capability (in support of manned platforms); human machine interface enhancements; development and integration of a secure Common Data Link-based network system; and development of operation and maintenance systems, processes, and tests to operationalize the evolving Manned-Unmanned Teaming capability.

Accordingly, the committee directs the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics to submit a report to the House Committee on Armed Services not later than April 1, 2020, on the Air Force's efforts for the design, test, and integration of these air vehicles.

#### *Major test range and facility enhancements*

The budget request contained \$717.9 million in PE 65807F for Department of the Air Force test and evaluation support. The committee notes that this amount is \$25.1 million, or approximately 3 percent, higher than the budget for fiscal year 2019.

In the committee report accompanying the National Defense Authorization Act for Fiscal Year 2018 (H. Rept. 115–200), the committee reported on a briefing it received on a comprehensive assessment of Major Range and Test Facility Base needs and investments to meet the testing required for advanced generation aircraft and air armaments, including offensive hypersonic weapons, autonomous systems, and advanced sub-surface systems. The committee noted that among its findings were that advanced generation aircraft and weapons introduce test and evaluation profile and data gathering gaps, and that greater research and development, operations and support investments are required to fill those gaps. The committee is further concerned that with a growing volume of test and training requirements, more instrumentation throughout test ranges, especially open-water test ranges, that support testing activities is required for efficient use of air, surface, and subsurface test areas to reduce the competition for range space between operational readiness priorities and fielding new system capabilities. The committee assesses that technologies such as Telemetry Extension Satellite Communications Relay projects could assist range safety, testing and evaluation personnel executing over water missions supporting test events of long-range weapons, aircraft, and sea-surface platforms. The committee notes these technologies focus on prototype integration and modification of wave gliders by using an array of sensors, antennas, receivers, and transmitters to gather and transmit secure data. The committee is further concerned that the potential development of open-water energy projects has the potential to encroach and negatively impact military test and training operations, and expects the Secretary of the Air Force to thoroughly evaluate impacts of such projects on Air Force test missions.

Therefore, the committee recommends \$743.4 million, an increase of \$25.5 million, in PE 65807F for Air Force test and evaluation support to enhance open-air range test capabilities in the development of next-generation platforms and air armaments and to mitigate growing open-water test range challenges and risks.

*Metals Affordability Initiative*

The budget requested contained \$36.6 million in PE 63112F for Advanced Materials for Weapons System.

The committee recognizes the importance of this program in providing affordable materials and manufacturing technologies across the entire life-cycle of aerospace materials. Specifically, the Air Force Research Lab-managed Metals Affordability Initiative has reduced metallic aircraft component costs and accelerated the implementation and transfer of technologies across a wide range of aircraft platforms. The committee notes the value of this public-private partnership and the risk sharing model that has directly led to a nearly \$2.4 billion return on the U.S. Government's investment. The committee recommends the Secretary of the Air Force create a dedicated funding line for the Metals Affordability Initiative to show the Air Force's clear commitment to this program.

The committee recommends \$41.6 million, an increase of \$5.0 million, in PE 63112F for Advanced Materials for Weapons System.

*Modular Open Systems Architecture Intelligence Sensor Readiness Initiative*

The committee is pleased by the recent memorandum from the Secretaries of the military departments supporting a move to Modular Open Systems Architectures (MOSA). Many of today's Air Force Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) gathering systems are built by single vendors who have a lock on future enhancements and capability drops. Obsolescence and vendor-lock lower the Air Force's capability and increase its operation and maintenance costs. Platform agnostic MOSA standards have the ability to enable airborne C4ISR systems to be fielded at a quicker pace while lowering logistics and procurement costs. The committee believes that the Department should endeavor to move away from stove piped systems and reduce dependence on single vendors and that MOSA would enable the Air Force to swap out capabilities and take advantage quickly of new innovations. The committee encourages the Air Force to establish a 3- to 5-year technical refresh cycle, versus the current 10-plus year cycles, and work to reduce its logistical overhead by taking advantage of common hardware and software, reduced maintenance, enhancement, and upgrade costs.

*OC-135B Open Skies Treaty aircraft recapitalization*

The committee notes that the current fleet of OC-135B aircraft conducting the Open Skies Treaty flights are over 55 years old and experience significant sustainment and reliability issues, resulting in an average mission completion rate of 65 percent between 2007 and 2017. Further, the range of the legacy OC-135 aircraft is insufficient to fully execute mission options within the treaty's 96-hour in-country observation period. In addition to maintenance and range limitations, the current wet-film imaging used to collect data

will become obsolete sometime around 2022. To avoid any gap in Open Skies Treaty collection capability, the committee supports the Air Force's plan to upgrade the fleet with digital visual imaging systems (DVIS) for the near-term, and ultimately replace the OC-135 Open Skies aircraft with two commercially-available small airliner class aircraft with integrated DVIS sensors.

The committee supports recapitalization of the OC-135 but remains concerned about the Air Force's ability to stay on schedule and meet the fiscal year 2022 aircraft certification and treaty compliance date. Unanticipated technical challenges with the DVIS sensors have already affected the schedule and could cause additional delays if not remedied soon.

Therefore, the committee directs the Secretary of the Air Force to provide a report to the House Committee on Armed Services by October 1, 2019, on the Open Skies Treaty aircraft recapitalization. The report shall include:

(1) an assessment of the DVIS data technical package maturity and the cost and feasibility of integrating it onto the replacement commercial aircraft;

(2) the plan for and status of developing or acquiring associated ground processing systems;

(3) the plan for management of programmatic risk and an assessment of the ability to meet the fiscal year 2022 deadline for an upgraded, treaty-compliant system;

(4) existing or planned mitigation options should the Air Force not be able to achieve current DVIS and treaty compliance milestones, and should there be any future delay to the upgrade or replacement of the OC-135; and

(5) a copy of any assessment conducted by an independent organization employed by the program for technical assistance.

#### *Open mission systems*

The committee supports the Department of Defense and each of the military services in their commitment to open-systems standards and the inclusion of those standards to the maximum extent possible in requirements, programming, and development activities for future weapon system modifications and new start development programs as agreed to in the January 2019 memorandum of understanding.

However, the committee notes that the military services are independently pursuing open-standards that are unique to each service, as the Air Force has focused efforts on the Open Mission Systems/Universal Command and Control Interface standard, the Army has focused on the VICTORY standard, and the Navy has focused on the Future Airborne Capability Environment standard. The committee further notes the open-standards as currently defined may not be interoperable and do not explicitly include requirements to ensure interoperability across services, thereby coupling warfighting capability to a specific standard and a specific service.

To accelerate and simplify the incremental delivery of new capabilities into systems across all military services, the committee recommends that the Department consider a cross-service interoperability requirement in future releases of their open standards and create a plan for identifying and managing compatibility across re-

leases of the standards. The committee further recommends that the Department identify current and future programs that would benefit from cross-service interoperability, such as the Air Force's Common Range Integrated Instrumentation System and the Navy's Tactical Combat Training System Increment II, and utilize these programs for experimentation, demonstration, and deployment of cross-service interoperable open standards.

*Persistent intelligence, surveillance and reconnaissance*

The committee remains concerned about the worldwide shortage of available intelligence, surveillance, and reconnaissance (ISR) assets to support combatant commander requirements. While the committee is encouraged by the Department of Defense's renewed prioritization in acquiring and fielding ISR assets, the committee also notes that the Department and each of the military services are developing and fielding programs to provide joint persistent ISR to the warfighter. The committee understands that one of the pathways identified in the Air Force's recently released Intelligence, Surveillance, and Reconnaissance Flight Plan is the use of multi-role and cross-domain ISR collection capability to increase readiness and lethality. The committee notes that these include high altitude assets and penetrating, persistent, multi-role capabilities. Therefore, the committee encourages the continued prioritization and funding for research and development of advanced ISR assets to include high-altitude, multi-day capable unmanned platforms, to fill existing persistent ISR capability gaps.

*Thermal management and robust power generation systems*

The budget request contained \$198.8 million in PE 62203F, and \$128.9 million in 62102F for the development and demonstration of electrical power, thermal management, and distribution for aerospace applications and materials.

The committee recognizes the Air Force is highly focused on developing next generation weapon systems, both for aircraft self-protection and to provide offensive capability for future aircraft. In order to meet these goals, the Air Force will need a power generation system that can meet these new power demands in addition to other electrical and avionic subsystems power requirements and will also need an efficient modular cooling system capable of handling increased thermal loads, specifically for hypersonic vehicles. The committee encourages the Air Force to focus developmental work on the aerospace electrical power and modular cooling technologies required for future aircraft concepts and cost-effective upgrades to current aircraft.

Therefore, the committee recommends an increase of \$5.0 million in PE 62203F to accelerate design, fabrication, and testing to support robust electrical power and thermal management systems for future aircraft needs, and an increase of \$10.0 million in PE 62102F for advanced thermal protections systems.

*Unmanned aerial systems cyber operations research*

The committee recognizes the critical importance of developing new technologies to detect and counter adversarial unmanned aerial systems (UAS) and UAS swarms. The committee notes that countering UAS operations presents a special series of unmet com-

munications, command and control, cyber, computation, and intelligence challenges at the tactical edge. Due to this emerging threat, the committee directs the Director of the Air Force Research Laboratory Information Directorate to provide a briefing to the House Committee on Armed Services by October 30, 2019, on their continued research and development into the countering of unmanned aerial systems using advanced technologies to facilitate UAS detection and geolocation, determination of individual and swarm behavior, dissection of swarms to identify critical nodes, situational awareness, elucidation of threats and mission intent, and counter UAS capabilities.

*Vertical lift demonstration*

The budget request contained \$102.9 million in PE 63211F for aerospace technology development.

The committee is aware of the Air Force's requirement for advanced technologies that provide the capability to operate from forward bases in highly contest environments with unimproved landing zones and limited maintenance facilities. A new class of runway independent aircraft could greatly enhance speed, range, and agility to support operations within these highly contested areas. The committee encourages the Air Force to continue research, development, and demonstration of next generation aircraft that are scalable, autonomous, and capable of vertical lift flight with high speed cruise performance.

Therefore, the committee recommends an increase of \$5.0 million in PE 63211F for aerospace technology vertical lift demonstrations.

*Wide area motion imagery*

The committee notes that the Gorgon Stare wide area surveillance capability continues to support daily operations in both Afghanistan and Iraq with critical intelligence, surveillance, and reconnaissance (ISR), and that other combatant commands have requested the Gorgon Stare capability. The committee is concerned that, despite daily operational tasking and despite the Air Force's designation of Gorgon Stare as a program of record in 2014, there is still no formal budget request for this combat-proven ISR system. The committee notes that prior year congressional funding has resulted in the system developing beyond line-of-sight communications and multi-intelligence capabilities.

Accordingly, the committee directs the Chairman of the Joint Chiefs of Staff to provide a briefing to the House Committee on Armed Services by November 1, 2019, on the plan for apportionment of Gorgon Stare into the Department's ISR forces and the full extent of combatant command requirements for Gorgon Stare ISR wide-area support to worldwide operations.

RESEARCH, DEVELOPMENT, TEST, AND EVALUATION, DEFENSE-WIDE

Items of Special Interest

*Additive manufacturing*

Defense-wide Manufacturing Science and Technology (DMS&T) is the joint, defense-wide component of the Department of Defense's Manufacturing Technology (ManTech) program directed by section

2521 of title 10, United States Code. Investments in ManTech provide for a healthy industrial base necessary for national security. The committee is aware that eight Department Manufacturing Innovative Institutes are funded under DMS&T, including an institute focused on additive manufacturing. The committee believes that additive manufacturing supports improved life-cycle maintenance and readiness, especially when capabilities are provided in-theater. Therefore, the committee directs the Under Secretary of Defense for Research and Engineering to provide a briefing to the House Committee on Armed Services not later than October 1, 2019, on the DMS&T program investments in additive manufacturing and the value and efficiencies such investments may have, especially when capabilities are provided in-theater.

#### *Advanced composites and manufacturing technologies*

The budget request contained \$10.1 million in PE 67210D8Z for industrial base analysis and sustainment.

The committee believes that advances in structural materials, composites, metals, ceramics, thermoplastics, nanomaterials, metamaterials, hybrid composites, and cellulose nanocomposites have the potential to transform manufacturing requirements for military weapon systems. These materials can be low-cost, low-weight, low-logistics, recyclable, corrosion resistant, and strong enough to have the potential to be used as a substitute in many military vehicles' primary structural applications and maintenance to maximize force projection through speed, range, enhanced mobility, and payload.

Additionally, the Department of Defense, through the Manufacturing Technology program, has worked in recent years to advance technology development for defense-essential manufacturing capabilities, cutting across all of the military services. Specifically, the Department has identified manufacturing technology requirements that would have the largest cost-effective impact on warfighter capability improvements.

These technologies potentially could enable the strategic goals of timely, affordable delivery of revolutionary technologies to the warfighter. Therefore, the committee recommends that the Department perform research, development, and testing on these advanced materials in order to demonstrate shorter development and manufacturing cycle times, more reliable joining methods, and optimization for desired performance and economical manufacturing.

Therefore, the committee recommends an increase of \$5.0 million in PE 67210D8Z for industrial base analysis and sustainment for smart digital manufacturing.

#### *AI-enabled Robotics in CBRN and Complex Environments*

The committee supports Department of Defense efforts to advance artificial intelligence (AI) and machine learning technologies in support of the National Defense Strategy and notes its commitment to rapid innovation and delivery of emerging capabilities to achieve military superiority over near-peer competitors. However, the committee also observes with interest the emerging application of AI enabled technologies to facilitate human-machine teaming for special operations forces operating in dangerous and non-permissive environments. For this reason, the committee encourages the

Department to pursue collaborative partnerships with small businesses, industry, and academia to aggressively develop and field AI enabled robotics to enable safer and more effective maneuver operations. The goal of these efforts should be to put revolutionary technology in the hands of warfighters to speed decision-making, increase lethality, and better enable complex tactical operations in contested or denied environments, especially those where chemical, biological, radiological or nuclear (CBRN) threats are present or where positioning, navigation and timing (PNT) services are degraded. Therefore, the committee directs the Undersecretary of Defense for Research and Engineering, in coordination with the Commander of U.S. Special Operations Command, to provide a briefing to the House Committee on Armed Services by November 1, 2019, on its strategy to leverage AI-enabled robotics in support of special operations forces and CBRN environments.

*Analysis of Science and Technology Reinvention Laboratories*

The committee recognizes that the Department of Defense's organic science and technology (S&T), research, development, and test ecosystem, to include the test centers and laboratories, struggles to compete with the tech sector in attracting and maintaining a talented workforce. These entities also face challenges in obtaining resources for military construction projects and other improvements as the Department has not prioritized investment in organic institutions. In fact, the Defense Science Board reported in 2017 that most Department laboratory directors feel they are unable to maintain their facilities and infrastructure at a reasonable standard.

The committee believes that the Department's in-house ecosystem is vital to maintaining a technological advantage for our warfighters, sustaining a healthy industrial base, and protecting the research and development of critical technologies. Many prior years' National Defense Authorization Acts have granted the Directors of the Science and Technology Reinvention Laboratories (STRLs) authorities to promote modernization and allow for hiring of technical talent. The committee understands most of these authorities have not been fully implemented by the Department and elsewhere in this Act, the committee includes two legislative provisions that would require the Secretary of Defense to establish plans for implementation.

The committee believes that comprehensive data and analysis relating to the STRLs available to senior leaders will promote better decision making and resource allocation to ensure these entities remain viable. Therefore, the committee directs the Director of Cost Assessment and Program Evaluation to conduct an independent analysis of the Department's STRL infrastructure, modernization, and workforce. The analysis shall include the components that comprise total costs at each facility; accounting practices with regards to direct and indirect costs as compared to other typical S&T entities; effects of labor cost-rate growth; the use of research and development funding for military construction projects; the loss of buying power on spending for materials, equipment and other non-labor resources; and any other matters deemed appropriate by the Director to maintain high-quality institutions. The Under Secretary of Defense for Research and Engineering shall provide the Director

with the information and resources necessary. The Director shall provide the analysis to the House Committee on Armed Services by September 1, 2021.

*Artificial intelligence in force protection activities*

The committee is encouraged by the ongoing rapid fielding of commercially-available technologies that utilize artificial intelligence (AI) and sensor fusion to deliver enhanced force protection for Department of Defense personnel and installations. Recent advances in commercially available technology, including artificial intelligence, computer vision, and sensor technology, have made it possible to develop, manufacture, and deploy more effective and cost-efficient Reconnaissance, Surveillance, and Target Acquisition technologies. Accordingly, the committee believes that AI can significantly improve situational awareness and security for Department of Defense personnel through faster and better processing and exploitation of sensor data, recognition and classification of potential threats, and dissemination of that information to human operators for the purposes of enhanced self-defense. The committee further believes that AI-based technologies for personnel security and base defense can provide more effective capability and will improve operators' ability to detect, classify, and respond to threats. The committee believes that the application of AI to improve the safety of Department of Defense personnel and installations is central to improving the security of military personnel and encourages the Department to consider these technologies in the continuous effort to enhance force protection.

*Autonomous distribution for critical supplies*

The committee is aware that the 2015 Joint Concept for Logistics 2.0 highlighted the growing gap between increasing logistics requirements and constrained logistics resources in the context of globally integrated operations. To close this gap, the Department of Defense is investigating advanced technologies suitable for distributed logistics. The committee understands that the Defense Innovation Unit has been prototyping commercial, autonomous drone services to deliver critical, life-saving supplies like blood and medical products to military units in combat zones. The committee supports the continued development and expansion of autonomous distribution systems for these efforts to move faster, reduce costs, and ultimately save lives. Therefore, the committee directs the Under Secretary of Defense for Research and Engineering to provide a report to the congressional defense committees by February 15, 2020, on efforts to modernize logistical operations since the publication of the 2015 Joint Concept for Logistics 2.0. The report shall include a summary of any prototyping efforts and an assessment of all missions and requirements that could be met through autonomous distribution technologies.

*Battery Development and Safety Enterprise*

The committee recognizes the importance of battery research and development as a readiness enabler. The committee notes that the military departments must be able to provide rapid, safe, and effective deployment of batteries and battery systems to support and enhance modern systems ranging from directed energy weapons to

microgrids. The committee further notes that research to develop advanced energy storage including safe storage and transport, facilitates the ability to field systems in austere environments. The committee commends the Navy for establishing the Battery Development and Safety Enterprise Office to address these issues in a systematic way with the added benefit of reducing life-cycle costs of battery usage enterprise-wide.

The committee recommends an additional \$13.0 million in PE 63724N for the Navy's Battery Development and Safety Enterprise Office. The committee encourages the Department of Defense to consider establishing a Battery Center of Excellence to benefit all services, encourage information sharing, and leverage efficiencies using the Navy's Battery Development and Safety Enterprise Office as its foundation.

#### *Chemical and Biological Decontamination Solutions*

The committee is aware of the Department of Defense's continuing interest in chemical and biological decontamination technologies. The Department has invested significantly in research and development efforts in academia, Department of Defense laboratories, and commercial industry. The committee understands there are a number of different domestic and foreign providers of chemical and biological decontamination solutions for the Department. The committee is interested in understanding the costs, benefits, and variances of these different solutions, including any impact on the domestic industrial base. Therefore, the committee directs the Secretary of Defense to provide a briefing to the House Committee on Armed Services by February 1, 2020, on the evaluation criteria for chemical and biological decontamination solutions procured by the Department, including an assessment of the cost, benefits, and any impact to domestic suppliers.

#### *Commercializing defense technologies*

The committee recognizes the value of defense research to the technological advancement and its history of ground breaking innovations that includes global positioning system navigation, the precursor of the Internet, and radar. These technologies that originated in the Department of Defense have had wide ranging impacts on society through their commercialization. The committee further recognizes that while significant effort has recently been made to streamline the use of commercial technology within the Department and in each of the military services, less attention has been given to commercializing defense technologies and continuing the Department's long record of successful innovation. The committee encourages the Department to create initiatives for commercialization of defense research, to include using public and private means and leverage the authorities provided in section 2359 of title 10, United States Code.

#### *Counterterrorism detection technology*

The budget request contained \$70.5 million in 63122D8Z for the Combating Terrorism Technical Support Office.

The committee recognizes the importance of identifying and developing capabilities to combat terrorism, particularly in the global fight against terrorism and protecting Americans at home and

abroad. The committee believes it is imperative that the Department of Defense continue to advance technological solutions to improve counterterrorism measures and deliver these capabilities to Department of Defense components and interagency partners. The committee is especially interested in the use of artificial intelligence enabled capabilities, including national language processing, phonetic identification across languages, and financial data tracking, that would provide the interagency real-time indications and warnings of possible threats or sanction violations.

Therefore, the committee recommends an increase of \$3.0 million in PE 63122D8Z for Combating Terrorism Technical Support Office detection technologies.

#### *Cyber institutes at senior military colleges*

The budget request included no funds for cyber institutes.

Section 1640 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115–232) authorized the Secretary of Defense to establish cyber institutes at each of the senior military colleges for purposes of accelerating and focusing the development of foundational expertise in critical cyber operational skills for future military and civilian senior leaders. The committee understands that the cyber institutes have not yet been established, but that the senior military colleges, as defined by section 1640, have a formal proposal for establishment.

The committee notes that women and minorities remain underrepresented in the cyber security sector in both military and civilian settings. To increase diversity and opportunity, the committee expects the Department to use the cyber institutes to conduct effective outreach, recruiting, and retention programs focused on increasing matriculation in and completion of cyber security programs by women and underrepresented minorities. The committee directs the Secretary of Defense to provide a briefing to House Committee on Armed Services not later than 180 days after the designation of cyber institutes on the strategy of each cyber institute to achieve diversity in the cyber security sector.

The committee recommends an increase of \$12.0 million in PE 303140D8Z for such institutes in order to facilitate development of critical cyber operational skills for future civilian and military leaders.

#### *Cyber-physical research*

The budget request contained \$121.5 million for applied research.

The 2018 Department of Defense Cyber Strategy highlights the Department's plan to strengthen the security and resilience of networks and systems that contribute to current and future U.S. military advantages and to support the development of the U.S. cyber workforce. As no system can be completely isolated from all cyberattacks, which continue to occur at unprecedented levels, there is also an evolving national requirement for cyber-physical security. Cyber-physical security is a combination of cybersecurity and systems engineering designed to ensure that critical cyber-physical systems, such as marine vessels, submarines, unmanned vehicles, and power grids, become more resilient to avoid or survive damage if they are attacked. Failure to protect these systems against inherent communication and control issues (e.g., network congestion and

real-time computing constraints) as well as malicious acts (e.g., cyberattacks) can have catastrophic consequences.

Therefore, the committee recommends \$129.5 million, an increase of \$8.0 million, in PE 0602123N for applied research into cyber-physical security.

#### *Directed energy test range workloads*

The committee remains concerned that U.S. Major Range and Test Facility Bases (MRTFBs) have inadequate infrastructure to support next generation weapon systems. The committee also recognizes the need to transition new and game-changing directed energy technologies to the warfighter. The Department of Defense established the Nation's first High Energy Laser System Test Facility (HELSTF) in 1975, but the technology has seen significant advancements over the course of four decades. As directed energy weapon systems mature, the need to validate their performance becomes increasingly important. The workload and number of directed energy demonstrations and exercises have increased significantly since 1975 and the projected workload for fiscal years 2018–22 for HELSTF is large and growing, and has expanded to include High Power Microwave (HPM) testing. Additionally, there are currently no available enduring frequency agile and tunable HPM assets for evolving doctrine or HPM Directed Energy Concept of Operations development any at MRTFBs.

The committee directs the Assistant Director for Directed Energy in the Office of the Under Secretary of Defense for Research and Engineering to provide a briefing to the House Committee on Armed Services not later than September 30, 2019, on the test and evaluation infrastructure and test asset needs to meet directed energy requirements over the next 5 years. Included in this briefing should be the plans for HELSTF and other service MRTFB test sites, to include HPM testing, required for directed energy experimentation in order to develop the tactics, techniques, and procedures required to incorporate the emerging capabilities into the Department's inventory. This presentation should also include mitigation procedures for operations in the national aerospace system against above-the-horizon targets.

#### *Electronic warfare planning for near-peer adversaries*

The Department of Defense's 2013 Electromagnetic Spectrum Strategy recognizes that Department operations in all domains are fundamentally dependent on our use and control of the electromagnetic spectrum. All joint functions such as movement and maneuver, fires, command and control, intelligence, protection, sustainment, and information are accomplished with systems that use the spectrum. The safety and security of U.S. citizens, the effectiveness of U.S. combat forces, and the lives of U.S. military members, our allies, and non-combatants depend on spectrum access. More recently, in December 2018, the Government Accountability Office issued an Emerging Threats report that similarly echoed that adversaries are developing electronic attack weapons to target U.S. systems with sensitive electronic components, such as military sensors, communication, navigation, and information systems. These weapons are intended to degrade U.S. capabilities and could restrict situational awareness or may affect military oper-

ations. The committee is concerned about the extent to which the Department is planning and preparing to defend itself and operate in an environment where peer and near-peer adversaries could use existing and emerging capabilities that degrade use of the electromagnetic spectrum.

Therefore, the committee directs the Comptroller General of the United States to assess the Department's electronic warfare and electromagnetic spectrum operations strategy and implementation efforts. The assessment should include the current electronic warfare threat from peer or near-peer adversaries and actions the Department has taken in response to include the protection of critical warfighting capabilities; the extent to which the Department has incorporated current and emerging electromagnetic spectrum risks into service and combatant command operational planning efforts and exercises; the status and effectiveness of the Electronic Warfare Executive Committee established by the Secretary of Defense in 2015; the Department's implementation of the 2013 Electromagnetic Spectrum Strategy; and any other matters the Comptroller General determines to be relevant.

The committee further directs the Comptroller General to provide a briefing to the House Committee on Armed Services not later than March 1, 2020, on preliminary findings, and to present final results in a format and timeframe agreed to at the time of the briefing.

#### *Energy systems for forward and remote operating bases*

The committee is aware of the Defense Science Board Study examining energy systems for forward and remote operating bases and encourages the Department of Defense to continue to invest in alternatives to improve the energy effectiveness of expeditionary forces. The committee is also aware of the Defense Science Board conclusion to explore the use of micro-nuclear reactors as an expeditionary energy source. The Department's Strategic Capabilities Office has released a Request for Information as to the feasibility of small nuclear reactor prototype demands that could meet the increasing energy demands of expeditionary operational units. The committee recognizes the urgent need to provide energy to remote operating locations to minimize the use of fuel and resupply land transport missions, as well as provide a rapidly deployable energy source during humanitarian relief operations, and urges the Department to consider options to meet this demand, including benefits, risks, operational requirements, safety and costs.

#### *Hacking for Defense*

The budget request contained \$25.0 million in PE 63950D8Z for the Hacking for Defense (H4D) National Security Technology Accelerator within the National Security Innovation Network program.

The committee believes that the H4D program is an innovative, educational, low cost, and exciting introduction to challenging national security problems for college students. H4D is a university course developed by U.S. military combat veterans and taught at 22 universities around the country, in which students apply cutting edge research and problem solving techniques to real-world security problems. Currently in its third year, the requested funding

will make it possible to scale up H4D training and ensure that courses are available year-round in every State.

Therefore, the committee recommends \$30.0 million, an increase of \$5.0 million, in PE 63950D8Z for the H4D National Security Technology Accelerator within the National Security Innovation Network program.

*Hacking for Defense Support to Defense Innovation*

The committee notes that Hacking for Defense (H4D) is authorized as a National Security Innovation and Entrepreneurial Education Program in the National Defense Authorization Act for Fiscal Year 2018 (Public Law No. 115–91) to enable Department of Defense innovation. H4D is a university course developed by U.S. military combat veterans and private sector entrepreneurs taught at universities across the United States in which students apply cutting-edge problem solving techniques to real-world national security and defense problems. The committee believes that H4D also enhances innovation education at military universities, including the United States Military Academy at West Point, the United States Air Force Academy, the National Defense University, the Defense Acquisition University, and other professional military education programs. The committee finds that H4D supports solution development directly for the warfighter, improves U.S. military readiness, and stimulates growth within the National Security Innovation Base, consistent with the 2018 National Defense Strategy. Further, the committee believes H4D fosters the growth of an emerging generation of national security leaders and mission-driven entrepreneurs by improving and expanding the Science, Technology, Engineering, and Math (STEM) skill sets within the United States workforce.

The committee believes that the Department of Defense should fully resource H4D and its growing ecosystem of national security innovators and entrepreneurs through the provision of the annual funding required to enhance existing H4D university courses. The committee notes that the National Security Innovation Network (formerly the MD5 National Security Technology Accelerator) plans to deliver H4D at up to 25 universities in Academic Year 2020–2021, as described in the President’s Budget Request for Fiscal Year 2020, and which the committee supports. Further, the committee directs the Secretary of Defense to provide a report to the congressional defense committees by December 1, 2019 on the plan to expand H4D as described in the President’s Budget Request for Fiscal Year 2020, and on the funding and other resources required to expand Hacking for Defense to at least 25 additional universities by Academic Year 2025–2026.

*Historically black colleges and universities and minority serving institutions*

The budget request contained \$30.7 million in PE 61228D8Z for research work with historically black colleges and universities and minority serving institutions (HBCU/MI).

The committee recognizes the important role this program plays in bolstering the research capabilities at HBCU/MIs. Not only is such work important in meeting the research needs of the Department of Defense, the committee also believes it provides an added

benefit by diversifying the Department's supply of scientists, engineers, and researchers working on the its most challenging problems.

The committee also acknowledges the ongoing efforts of the Department to increase the participation of women from underserved populations in science, technology, engineering, and mathematics (STEM) related areas of research. The committee urges the Department to continue funding for Center of Excellence efforts at historically black colleges and universities that support training and education of minority women in STEM fields of interest to the military, particularly through research funding, fellowships and internships, and cooperative work experiences at the Defense Laboratories. The committee recommends that the Department consider increasing investments in these kinds of activities in future budgets to support Administration initiatives on HBCU/MIs.

The committee additionally recommends that the Department strengthen its engagement and investments via the quantity and value of grants, studies, technical support contracts, and sub-contracts with HBCU/MIs with a goal of elevating the quality of research and scientific activity at those institutions to the R1 and R2 level of the Carnegie Classification of Institutions of Higher Education. Therefore, the committee directs the Under Secretary of Defense for Research and Engineering to submit a report to the congressional defense committees by March 1, 2020, on how the Department can expose HBCU/MIs to new levels of research and scientific problems for the benefit of the Department.

In addition, the committee recommends \$50.7 million, an increase of \$20.0 million, in PE 61228D8Z for additional research between HBCU/MIs, and increased teaming opportunities between these institutions and other research universities with experience supporting the Department's unique requirements. This amount is above the enacted budget of fiscal year 2019.

#### *Human simulation and human factors modeling*

Section 227 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115-232) required the Secretary of Defense to develop and provide for the carrying out of human factors modeling and simulation activities with the purpose of accelerating research and development to enhance capabilities for human performance, human-systems integration, and training for the warfighter. The committee directs the Secretary of Defense to provide a briefing to the House Committee on Armed Services not later than January 30, 2020, on the status of this requirement. Specifically, the committee would like to know the extent of the activities implemented, the effects as yet of these activities with respect to their purpose, which activity participants, locations of the activities, and the plan to sustain these activities going forward.

#### *Hybrid and electric air vehicle power and propulsion systems*

The committee understands that hybrid and electric power and propulsion systems and vehicles hold the potential to significantly increase range and endurance for military aviation. The committee believes such aviation capabilities could support the National Defense Strategy. The Department of Defense requires a process to certify airworthiness to allow flight testing of these systems. How-

ever, the committee notes that the Department lacks adequate design, test, and certification procedures and facilities for aviation-purposed electric motors, motor controllers, traction bus systems, and large primary power battery systems. The committee is concerned that without a certification process in place, the military may miss the opportunity to capitalize on these advanced systems to reduce logistical requirements and costs.

Therefore, the committee directs the Secretary of Defense to provide a report to the House Committee on Armed Services by February 1, 2020, on establishing procedures and facilities for airworthiness certification of hybrid and electric power and propulsion aviation systems. The report should include estimated cost and schedule to implement a certification process.

#### *Hypersonic test infrastructure and workforce*

The committee acknowledges the joint-effort to expand and develop conventional prompt strike capabilities (CPS), which was codified in a memorandum of agreement between the Department of Defense, military services, and the Missile Defense Agency to deliver hypersonic boost glide technology. To achieve success in the multiple service efforts to deliver CPS capabilities, the committee recognizes the importance of state-of-the-art facilities and infrastructure to support research, development, prototyping, testing, and deployment.

The committee notes that recent advances have been made in high temperature manufacturing, hypersonic wind tunnel capability and material testing technology. Specifically, the committee is encouraged by the Department's efforts to expand the number of hypersonic wind tunnel and testing facilities, specifically at Arnold Air Force Base Engineering Development Center and the joint-investment at several universities, including Purdue, Notre Dame, and Texas A&M. However, even with these increases, current facilities will be stressed to provide the level of testing needed across the joint-efforts.

In addition to the high demand for testing infrastructure, the U.S. currently lacks the workforce with sufficient knowledge and experience in hypersonic materials manufacturing and testing to develop these next generation systems. Therefore, the committee directs the Under Secretary of Defense for Research and Engineering, in coordination with the military services and Missile Defense Agency, to provide a report to the House Committee on Armed Services not later than December 31, 2019, on the health of hypersonic testing technologies and workforce. The report should include an analysis of current capacity to meet existing requirements, options to improve testing facilities, with cost, schedule, and operational considerations, and efforts that are being taken to address workforce gaps.

The committee also acknowledges that System Integration Labs are necessary to support testing of hypersonic weapon systems, specifically for the U.S. Army as it proceeds with the long range hypersonic weapon. Therefore, the committee directs the Commander of U.S. Army Space and Missile Defense Command to provide a briefing to the House Committee on Armed Services not later than December 31, 2019, on capability and capacity assessments to support future ground testing. The briefing should include

an analysis of integrated hardware and software processes and system integration and development.

*Implementation of existing authorities for the science and technology reinvention laboratories*

The committee understands that the Department of Defense's in-house science and technology (S&T) ecosystem, to include the science and technology reinvention laboratories (STRs), suffers from the common struggle to compete with the tech sector in attracting talented Innovation, Science, Technology, Engineering, Math (iSTEM) trained researchers and scientists. Yet the committee is frustrated that the military services have yet to use many of the authorities and responsibilities granted in previous National Defense Authorization Acts, such as:

(1) personnel hiring authorities, including the authorities provided under: section 1599h, 2358a, and 2360 of title 10, United States Code; section 1109 of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114-92); and section 1124 of the National Defense Authorization Act for Fiscal Year 2017 (Public Law 114-328);

(2) the authority to enter into partnerships with institutions of higher education, including the authorities provided under section 2194 of title 10, United States Code; section 236 of Public Law 114-328;

(3) the authority to reengineer management and business processes, including the authorities provided under section 2368 of title 10, United States Code; sections 211 and 233 of Public Law 114-328;

(4) the authority to carry out prize competitions, including the authority provided under section 2374a of title 10, United States Code;

(5) the authority to make technology transfers, including the authority provided under section 233 of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115-91); and

(6) defense-wide authorities, including the authorities provided under sections 217 and 232 of Public Law 115-91.

Therefore, elsewhere in this title, the committee includes a provision that would require the Secretary of Defense to develop a master plan for using current authorities and responsibilities to strengthen and modernize the workforce and capabilities of the Department's STRs to enhance the ability of the laboratories to execute missions in the most efficient and effective manner. The provision would require the Under Secretary of Defense for Research and Engineering to submit the master plan for using these authorities and a report on the Department's progress in implementing these authorities to the congressional defense committees not later than October 30, 2020.

*Integrated Silicon-Based Lasers*

The committee is aware that the Department of Defense's weapons platforms, such as aircraft and radars, are still largely burdened with difficult to install and maintain, slow, expensive, and heavy copper wire cabling. The Department's initial investments in Integrated Silicon-Based Lasers have identified opportunities for transforming the state-of-the-art in the manufacture of integrated

photonics devices. Integrated Photonics, the use of light for applications traditionally addressed through electronics, is used in a wide range of areas including telecommunications; 5G cell towers; cell phones; military laser-based radars; data communications; sensing; and could be used to replace heavy coaxial cabling in aircraft with fiber optic cables that are significantly smaller and lighter.

The committee directs the Under Secretary of Defense for Research and Engineering to submit a report to the House Committee on Armed Services by April 30, 2020, on how future military and commercial applications could use integrated photonics to benefit from higher bandwidth of data transfer, faster data transmission, and lower energy loss due to optical fiber being more energy efficient and lower weight than copper.

#### *Investments in Science and Technology*

The Department of Defense's Science and Technology (S&T) ecosystem is complex and is comprised of agencies, offices, laboratories, federally funded research and development centers, university affiliated research centers, academic partnerships, test and evaluation entities, and partnerships with the private sector to include small businesses. The Department's S&T ecosystem is charged with delivering the best capabilities to the warfighter in the near-, mid-, and long-term.

However, Defense Planning Guidance issued by the Under Secretary of Defense for Policy has for many years mandated only a base of zero percent real growth in the annual S&T budget. The fiscal year 2020 budget request for S&T was only 2.7 percent of the Department of Defense's base budget request and only 3.2 percent above the fiscal year 2019 requested funding level. Adjusted for inflation, the fiscal year 2020 request was only 1 percent higher than the fiscal year 2019 budget request.

The committee is concerned that the lack of growth negatively impacts the ability of the Department to keep pace with the real-world cost increases in the S&T ecosystem, such as the ability to attract highly specialized technical labor like scientists and engineers with advanced degrees and PhDs, and maintain a technological edge.

The committee is disappointed that this year's Defense Planning Guidance removed the base requirement of zero percent real growth. The committee is concerned that future budgets will show negative real growth and the Department's investments in its future technological edge will be even more dire. Therefore, the committee directs the Director, Cost Assessment and Program Evaluation, with analytical and resource support from the Under Secretary of Defense for Research and Engineering, to conduct a study and provide a briefing to the House Committee on Armed Services not later than September 1, 2021, on the effects of the Department submitting future budget requests with negative real growth in the Department's funding for S&T efforts.

#### *Joint Electromagnetic Spectrum Operations*

Joint Electromagnetic Spectrum Operations (JEMSO) include all activities in military operations to successfully plan and execute joint or multinational operations to control the electromagnetic operational environment. Electronic warfare planning and manage-

ment tools can be customized for different services and fielded in almost any deployment environment. Joint electronic warfare planning and management tool technology demonstrations are good initial steps towards managing technologies across a broader integrated electronic warfare system, which have the potential to neutralize and exploit enemy signals and equip combat forces with essential electronic warfare mission-planning capabilities. The committee therefore recommends expeditiously establishing joint electromagnetic spectrum operations cells at the combatant commands and ensuring they are equipped with the right resources and technology to successfully meet mission needs.

#### *Joint Threat Warning System*

The committee recognizes that the Joint Threat Warning System (JTWS) provides credible threat warning and intelligence information to special operations forces (SOF). The committee notes that this program has been critical to enhancing the situational awareness of SOF elements by alerting them to threats to the force and illuminating targeting opportunities. The committee is concerned that the program does not include an air-variant precision high frequency band capability. This gap in coverage exposes SOF operators to unknown threats and decreases their situational awareness. Therefore, the committee directs the Commander, U.S. Special Operation Command to provide a briefing to the House Committee on Armed Services not later than December 1, 2019, on efforts to address this critical air-variant high frequency gap in coverage.

#### *Lithium-ion batteries*

The budget request contained \$10.0 million in 67210D8Z for industrial base analysis and sustainment support.

The committee understands that a viable, domestic source of lithium-ion batteries is critical to national security and Department of Defense manufacturing. Advances in battery cell manufacturing using modern equipment has the potential to increase the readiness and performance of essential Department of Defense warfighting capability that relies on safe, high-performance portable power. The committee notes that the advances in modern manufacturing equipment will ensure the supply of domestically produced lithium-ion batteries and secure a competitive domestic industrial base. Additionally, the committee understands that the military services have an important role communicating that rapid, safe, and effective deployment of batteries and battery systems is essential to support and enhance the lethality of weapons systems. The committee further notes that development of advanced energy storage systems that facilitate safe storage and transport of these batteries is a critical element of this effort. The committee understands that energy storage and thermal management are essential to both future weapon systems and microgrids. The committee applauds the Navy's effort to address these issues through the establishment of a battery office dedicated to addressing these issues and reducing the cost of battery usage enterprise-wide through the development and implementation of batteries and battery storage systems.

Therefore, the committee recommends an increase of \$4.0 million in PE 67210D8Z for industrial base analysis and sustainment support related to lithium-ion battery manufacturing.

#### *Microelectronics*

The committee recognizes that microelectronics technology provides critical capabilities to Department of Defense, other government organizations' systems, and the commercial marketplace. With China's declared policy and commitment of dominating microelectronics market by 2025, the committee remains concerned with the Department of Defense's long-term strategy to maintain supply chain integrity and assurance against counterfeit parts and ensure continued access to trusted microelectronics. The committee is also concerned about the Department of Defense's lack of a robust industrial base and domestic supply chain for radiation-hardened microelectronics. The Department relies extensively on weapon and communications systems that must operate in high ambient radiation levels for national security, surveillance, battlefield communications, and missile defense. While there have been a number of attempts to address the challenges associated with the domestic microelectronics industry, the onset of 5G and the national security concerns associated with use of commercial microelectronics devices in military and other sensitive national security systems have increased the immediacy and level of concern. The committee supported the requirement in section 231 of the National Defense Authorization Act for Fiscal Year 2017 (Public Law 114-328) requiring the development of a microelectronics strategy. However, with the introduction and proliferation of 5G technologies, the strategy must be updated.

Therefore, the committee directs the Secretary of Defense to provide a briefing to the House Committee on Armed Services not later than February 15, 2020, on the Department's Trusted Microelectronics strategy. The briefing should include the original elements of the strategy including supplier base capacity and need for trusted, radiation-hardened and anti-tamper microelectronics, and also address how the onset of 5G technologies is changing the national security and commercial marketplace for trusted microelectronics.

#### *Military rotorcraft safety*

The committee recognizes that military rotorcraft operate in hazardous conditions using special tactics, techniques, and procedures that can lead to increased risk for pilots and their crews. The committee is aware of the significant risk that uncharted wires and obstacles pose to military rotorcraft, especially those flown by special operations forces and combat search and rescue elements. The committee also notes that military rotorcraft face safety and readiness challenges stemming from excessive aircraft vibration. The committee further understands that current vibration mitigation efforts often seek to mask or absorb vibrations without resulting in an actual decrease in vibration. The committee is concerned that there is insufficient focus on developing and fielding effective technology for detecting uncharted wires and obstacles, as well as insufficient focus on developing materiel solutions to help mitigate excessive vibration in legacy rotorcraft platforms.

The committee directs the Secretary of Defense, in coordination with the Secretaries of the Army, Navy, and Air Force, to provide a briefing to the House Committee on Armed Services by February 1, 2020, on Department-wide efforts to identify, develop, and procure capabilities related to the detection and avoidance of uncharted wires and obstacles, as well as efforts to mitigate excessive vibration in rotorcraft. The briefing should include to the maximum extent practicable an evaluation of current commercially available systems for obstacle detection and analysis of any tools, processes, software, or methodologies currently being evaluated towards mitigating vibration levels.

*Moving Target Defense*

The budget request contained \$81.8 million in PE 603563N for Ship Concept Advanced Design.

The committee supports the Department's efforts to explore alternatives to traditional cyber defense architectures and approaches to mitigate cyber vulnerabilities. The committee encourages the Secretary of Defense to continue to explore and invest in cyber technology that provides multi-tiered defensive capabilities, such as moving target defense.

The committee recommends an increase of \$5.0 million, in PE 603563N, for Moving Target Defense technology.

*National Academies Science, Technology, and Security Roundtable*

The budget request contained \$16.9 million in PE 65798D8Z for Defense Technology Analysis.

Intellectual property theft and counterintelligence threats pose significant challenges to maintaining a United States technological edge. To that end, the committee mandated the Department of Defense establish an initiative to support protection of national security academic researchers from undue influence and other security threats in section 1286 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115–232). The committee is aware that implementation of this initiative, specifically gathering information on persons performing Department of Defense research at universities and participants of foreign talent programs, has presented policy challenges relating to privacy and civil liberties, and sharing of data between federal agencies. The committee is also aware that sharing of threat information by the Federal Government to academia has not increased through this initiative and believes that efforts under this initiative would be more effectively executed with the inclusion of appropriate domestic law enforcement agencies and entities, such as the Federal Bureau of Investigation.

Therefore, the committee supports the Secretary of Defense convening a National Science, Technology, and Security Roundtable through the National Academies of Science, Engineering and Medicine in order to facilitate dialogue and formulate solutions related to protecting U.S. critical technology and national security information while simultaneously preserving civil liberties and an open science and technology research environment. The committee believes that key stakeholders from the interagency and scientific and academic communities, as well as foreign partner and allies should be part of this roundtable.

The committee therefore recommends \$19.9 million, an increase of \$3.0 million, in PE 65798D8Z for the Secretary to convene the National Science, Technology, and Security Roundtable through NASEM.

*National Consortium for the Study of Terrorism and Responses to Terrorism*

One of the key tenants specified in the 2018 National Defense Strategy (NDS) is reforming the Department of Defense for greater performance and affordability. In the NDS, the Department acknowledged that an increasingly complex security environment, coupled with the need to modernize and improve readiness, are among the factors that will require difficult and informed prioritization decisions. Machine learning and related concepts offer promise to deliver data driven decision making tools where the potential consequences and risk of selected actions can be evaluated in real time based on a wide variety of input sources and emerging conditions.

The committee is aware the Department has been investing in the National Consortium for the Study of Terrorism and Responses to Terrorism (START) and is the largest consumer of data from this program. START is a university-based research and education center that provides an effective resource that has informed current counterterrorism policies and strategy. Aligning with the objectives specified in the National Defense Strategy, this funding has supported a robust and versatile decision matrix created by leading social scientists from more than 50 academic and research institutions across the country and around the globe.

For example, one of the effective elements within START is the Leadership of the Extreme and Dangerous for Innovative Results Dataset and Collection, developed to assess and better understand the motivations and maneuvering of the leadership of current and emerging Violent Extremist Organizations, such as the Islamic State of Iraq and the Levant. The research provides an analytical framework and risk based consequence management prediction capability that has been tested and proven effective on battlefields around the globe.

The committee believes that because of the success and maturation of START's analytical framework, as well as its multi-disciplinary approach, there may be alignment with other Department funded priorities. The committee notes that there could be benefit in using the program as a prototype for other applications that require a mission focused capability that crosses functional domains and enhances warfighter lethality, technical superiority, adaptability, and resilience. Therefore, the committee encourages the Department to evaluate and fully fund a prototype using the START database foundation as a consequence management counterterrorism decision support application.

*National Defense Education Program*

The budget request contained \$92.1 million in PE 61120D8Z for the National Defense Education Program (NDEP).

NDEP fosters and enhances the Department of Defense's ability to access high-quality science, technology, engineering, and mathematics personnel vital to national defense now and in the future.

This is accomplished through initiatives such as the Science Mathematics and Research for Transformation program, a scholarship-for-service program, as well as the Military Child Pilot Program formally established by section 233 of the National Defense Authorization Act for Fiscal Year 2015 (Public Law 113–291). The committee believes that investments in science, technology, engineering, and mathematics education to develop a future technical workforce are critical to maintaining a technological edge.

Therefore, the committee recommends \$112.1 million, an increase of \$20.0 million, in PE 61120D8Z for NDEP.

*Optical fiber in next generation information infrastructure*

The committee is aware of the significant wired and wireless information infrastructure deployments that will be required to operate a robust, secure next generation 5G network. As the Department of Defense increases investments in next generation information technology research and development, it will be critical that the Department also understand the strategic industries that will be required to grow and sustain this technology modernization. One of these critical technologies is the optical fiber industry, which will form the backbone of the wired 5G infrastructure for national security applications. The committee encourages the Department of Defense to consider the security implications of foreign optical fiber on 5G modernization and the importance of maintaining a secure, domestic industrial base for optical fiber.

*Pilot Program for Supply Chain Awareness and Cybersecurity in the Defense Industrial Base*

The budget request contained \$40.1 million in PE 64771D8Z, for the Joint Tactical Information Distribution System, which includes funds for cybersecurity support to the Defense Industrial Base.

The committee recognizes the thoughtful approach that the Department of Defense has taken on its pilot program, Cyber Maturity Model Certification (CMMC). This program managed by the Under Secretary of Defense for Acquisition and Sustainment has brought together experts from academia and the private sector to create a framework for evaluating a defense contractor's cybersecurity posture. The program recognizes the challenges of robust cybersecurity programs for small and medium-sized businesses seeking opportunities with the Department of Defense, while ensuring that cyber risk to Department equities is managed appropriately. As this program continues to evolve in its development, the committee expects the Department to provide regular briefings on the program's status.

The committee recommends \$43.1 million, an increase of \$3.0 million, in PE 64771D8Z to support the Department's program.

*Protecting Critical Technologies Task Force*

According to a memorandum issued by the Secretary of Defense on October 24, 2018, "each year, it is estimated that American industry loses more than \$600 billion to theft and expropriation. Far worse, the loss of classified and controlled unclassified information is putting the Department's investments at risk and eroding the lethality and survivability of our forces." Protection of classified and controlled unclassified information, and intellectual property,

when appropriate, is necessary for the U.S. to maintain a warfighting advantage.

The committee believes that effective protection of appropriately designated information requires a comprehensive, data-based understanding of theft and exportation and that impacted entities, such as academia and the Defense Industrial Base, must be part of the Department's efforts to develop solutions. The committee further believes that privacy and civil liberties, as well as an open research environment, must not be compromised by efforts to protect information.

For example, the Department funds basic research that benefits greatly from the global science and technology ecosystem. National Security Decision Directive 189 on the National Policy on the Transfer of Scientific, Technical and Engineering Information from President Reagan's administration outlined that the products of "fundamental research," defined as "basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community," should remain unrestricted.

The committee is aware the Protecting Critical Technologies Task Force (PCTTF), established by former Secretary of Defense James Mattis, is one of the entities in the Department leading the effort to mitigate the loss of classified and controlled unclassified information. The committee supports the PCTTF and expects to be continually updated on its efforts. Additionally, the committee directs the Director of the PCTTF to provide a briefing to the House Committee on Armed Services not later than October 30, 2019, on efforts and progress to date.

#### *Protection of National Security Research*

The committee believes that institutes of higher learning, laboratories, and other entities and organizations play critical roles in advancing national security within the U.S. science and technology ecosystem that is charged with delivering the best capabilities to the warfighter in the near, mid, and long-term. The committee understands that near-peer competitors such as China and Russia attempt to exploit and benefit from the open and collaborative global research environment created by the Reagan Administration's National Security Decision Directive 189 on the National Policy on the Transfer of Scientific, Technical and Engineering Information, which established that the products of "fundamental research"—defined as "basic and applied research in science and engineering, the results of which ordinarily are published and shared"—should remain unrestricted.

The committee is also aware that academia is not always kept apprised by the interagency of a complete picture of potential activities and threats in the research community, such as improper technology transfer, intellectual property theft, and cyber-attacks directly affiliated with nation-state governments. Elsewhere in this bill and report, the committee includes measures to promote increased information sharing across the interagency and with academia.

The Committee therefore directs the Secretary of Defense to provide to the Committees on Armed Services of the Senate and House of Representatives, not later than January 1, 2020, a report listing

Chinese and Russian academic institutions that have a history of improper technology transfer, intellectual property theft, cyber espionage, or operate under the direction of their respective armed forces or intelligence agencies. The report should be in unclassified form, though it may contain a classified annex.

*Provision of Analysis to U.S. Humanitarian Demining Organizations*

The committee recognizes the prevalence and growing use of improvised threats in war and the work being conducted by humanitarian demining organizations, with support from the U.S. government, to alleviate the lasting impacts of such threats on civilian populations. The committee also recognizes the expertise of the Defense Threat Reduction Agency, Joint Improvised-Threat Defeat Organization Directorate (JD), which has conducted extensive research on these improvised threats.

Therefore, the committee directs the Director, JD, to submit a report to the House Committee on Armed Services not later than October 1, 2020 cataloguing previous JD research that could be released to U.S. humanitarian demining organizations to improve the efficiency and effectiveness of humanitarian demining efforts.

*Radio frequency countermeasures for rotary wing aircraft*

The committee supports the Department's commitment to modernizing the vertical lift and rotary-wing capabilities across the services. The committee also notes with concern the rapid development and proliferation of advanced radio frequency threat systems that would possess the ability to engage rotary-wing aircraft currently operated by the Army, Navy, Marine Corps and Air Force. Therefore, the committee directs the Secretary of Defense to provide a briefing to the House Armed Services Committee, no later than January 31, 2020, that includes: a near and long-term acquisition and development strategy to provide radio frequency countermeasure (RFCM) protection for current and future rotary wing aircraft for each of the military services. The briefing should also include all current rotary-wing RFCM production programs and address any additional applicable programs with mature technology readiness levels.

*Report on Designation of a National Center of Excellence for Pathogen and Microbiome Analysis*

The Committee is concerned that the Department has no central research center dedicated to dangerous pathogen and microbiome research; therapeutics and vaccine development; workforce education and training; and advanced computational analysis. The lack of a central laboratory that can handle and ship highly dangerous pathogens while employing the most advanced genomic, immunology, and computational analyses has resulted in a suboptimal effort to research, develop, test, and evaluate (RDT&E) some of the most lethal threats to the warfighter. The Committee believes that the lack of a central RDT&E Institute to coordinate nationwide efforts results in higher costs to the taxpayer.

The Committee believes that it is critical that the next generation of pathogen and microbiome researchers are educated through university partnerships, as neither the Defense Threat Reduction

Agency (DTRA) nor federal contractors have the tools for such training. Formally designating a university-housed Center of Excellence within DTRA would enable a central entity staffed with experts in different research disciplines to include immunology; vaccines; therapeutics; genomics; bioinformatics; disease models; and artificial intelligence to coordinate these many efforts without the need to create another entity within DTRA.

The Committee therefore directs the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, with support from the Director of DTRA, to submit a report by December 31, 2019 to the Committees on Armed Services of the Senate and House of Representatives on the benefits and feasibility of designating and funding an existing operational entity which has a proven record of zero violations for safety, shipping, and compliance as the National Institute for Pathogen and Microbiome Analysis under DTRA to coordinate, focus, and assist DTRA's RDT&E efforts to protect warfighters from biological threats.

#### *Role of universities in rapid prototyping*

The committee recognizes that the ability to rapidly prototype services, technologies, and systems is critical to expanding warfighting capabilities by reducing time and cost to field systems. While the Department of Defense engages with the university community in support of basic research and workforce development, the committee believes universities can also contribute to rapidly integrating existing and new technologies into the Department's systems. The committee encourages the Department to explore the establishment of partnerships with academia under a university consortium, cooperative agreement, or multi-institution task order contract model, as authorized in section 217(e) of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115-91), to rapidly prototype services, technologies, and systems with national security applications into Department of Defense command, control, communications, computers, cyber, and intelligence systems and infrastructure.

#### *Tactical data links*

The committee remains concerned with the lack of a Department of Defense-wide, comprehensive effort to achieve a resilient and survivable network for 5th and 4th generation systems data sharing in a highly contested operational environment. Section 234 of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115-91) directed the then-Under Secretary of Defense for Acquisition, Technology, and Logistics to coordinate with the Secretary of the Navy and the Secretary of the Air Force to develop a competitive acquisition plan for low probability of detection/low probability of intercept (LPD/LPI) datalink network capability. The committee notes, however, that the Department's plan was not sufficient or comprehensive.

The National Defense Strategy's shift to peer and near-peer threats requires joint force capabilities for operations in highly contested environments. The F-22 and the F-35 aircraft possess LPD/LPI datalinks, but their two systems, the Intra-Flight Data Link and the Multifunction Advanced Data Link (MADL), cannot share information between aircraft. The Department identified F-35's

MADL as the preferred airborne datalink to meet the requirement, but the associated form, fit, and function changes required rendered this unaffordable and the effort was cancelled. Additionally, the Air Force's concept for an Advanced Battle Management System (ABMS) for battle management and command and control (BMC2) also depends upon LPD/LPI datalinks to exchange intelligence, surveillance, and reconnaissance (ISR) and BMC2 information between current and future sensor network nodes.

The committee believes LPD/LPI networked communications must be a priority, and therefore, directs the Under Secretary of Defense for Acquisition and Sustainment, in coordination with the Secretaries of the Air Force and Navy, to provide a report to the congressional defense committees by December 1, 2019, on plans to ensure LPD/LPI communications among and between 5th and 4th generation airborne platforms as well as other network nodes for command, control, communications, and intelligence, surveillance, and reconnaissance. The report shall include:

(1) all current and planned LPD/LPI data link developments, with requirements, technology specifications and readiness levels, and applicability to specific platforms and network-enabled weapon systems;

(2) a plan and schedule for flight testing the data links in operationally relevant environments; and,

(3) estimated cost and schedule to implement each solution.

#### *University and industry research centers*

The budget request contained \$86.2 million in PE 61104A for University and Industry Research Centers.

The committee is concerned that although many valuable innovations, such as combat gauze and tourniquets, have derived from lessons learned on the battlefield and are now commercially available, many more get lost in institutions, laboratories, and the "Valley of Death". Key components of accessing capital, sharing information on current military medical gaps and private-sector capabilities to address them, forming synergistic collaborations across academic institutions, businesses and government, and providing guidance to entrepreneurs and start-ups all remain essential to enable innovations to transition for Military Medical Innovations. Additionally, university and industry research centers of excellence conduct a wide range of research to advance technology in support of the Army's modernization priorities.

The committee recommends \$91.2 million, an increase of \$5.0 million, in PE 61104A for University and Industry Research Centers to help address the challenges to expand the entrepreneurial ecosystem to address unmet needs for the Department of Defense and produce dual-use innovations.

## LEGISLATIVE PROVISIONS

### SUBTITLE A—AUTHORIZATION OF APPROPRIATIONS

#### Section 201—Authorization of Appropriations

This section would authorize appropriations for research, development, test, and evaluation at the levels identified in section 4201 of division D of this Act.

SUBTITLE B—PROGRAM REQUIREMENTS, RESTRICTIONS, AND  
LIMITATIONS

Section 211—Program on Enhancement of Preparation of Dependents of Members of Armed Forces for Careers in Science, Technology, Engineering, and Mathematics

This section would make section 233 of the Carl Levin and Howard P. “Buck” McKeon National Defense Authorization Act for Fiscal Year 2015 (Public Law 113–291) permanent. Section 233 created a pilot program on enhancement of preparation of dependents of members of Armed Forces for careers in science, technology, engineering, and mathematics (STEM). The program improves STEM learning and performance for children; helps retain service members; provides STEM education opportunities to children in lower socioeconomic communities from which the U.S. military recruits heavily; and is a national level curriculum that works well for families that move around the country.

The committee expects the Secretary of Defense to continue to coordinate with other government organizations and departments as appropriate, to include the Secretary of Education, the National Science Foundation, and the heads of such other Federal, State, and local government and private sector organizations as the Secretary of Defense considers appropriate. Additionally, the committee expects the Secretary to continue, to the maximum extent practicable, to make use of the authorities under chapter 111 and sections 2601, 2605, and 2374a of title 10, United States Code, section 219 of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 (10 U.S.C. 2358), and such other authorities as the Secretary of Defense considers appropriate.

Section 212—Temporary Inclusion of Joint Artificial Intelligence Center of the Department of Defense in Personnel Management Authority to Attract Experts in Science and Engineering

This section would extend personnel management authorities to the Director of the Joint Artificial Intelligence Center to facilitate recruitment of eminent experts in science or engineering through December 31, 2024.

Section 213—Joint Hypersonics Transition Office

This section would amend section 218 of the John Warner National Defense Authorization Act for Fiscal Year 2007 (Public Law 109–364) by directing the Department of Defense to establish a coordinating office that standardizes the technical priorities across the Department and provides discretionary authorization of funding of new technologies for expeditious transition to the service weapons systems.

Section 214—Modification of Proof of Concept Commercialization Program

This section would amend section 1603(g) of the National Defense Authorization Act for Fiscal Year 2014 (Public Law 113–66) by extending the Proof of Concept Commercialization Pilot Program

through 2024 and amending the title of the section heading by inserting “of Dual-Use Technology” after “Commercialization.”

#### Section 215—Contract for National Security Research Studies

This section would direct the Secretary of Defense, acting through the Under Secretary of Defense for Acquisition and Sustainment, to seek to enter into a contract to support the JASON scientific advisory group, and would require notification to the congressional defense committees 90 days before termination of such contract. The committee also expects the Department of Defense to provide notification to the congressional defense committees if the contract expires without renewal.

#### Section 216—JASON Scientific Advisory Group

This section would require the Secretary of Defense to seek to engage the members of the private scientific advisory group known as “JASON” as advisory personnel to provide advice, on an ongoing basis, on matters involving science, technology and national security.

#### Section 217—Direct Air Capture and Blue Carbon Removal Technology Program

This section would authorize a program for carbon capture from the sea to support energy security and increase the efficiency of forward deployed units.

#### Section 218—Foreign Malign Influence Operations Research Program

This section would require the Under Secretary of Defense for Research and Engineering to carry out a research program on foreign malign influence operations research as part of the university and other basic research programs of the Department of Defense, such as the Minerva Research Initiative.

#### Section 219—Sensor Data Integration for Fifth Generation Aircraft

This section would require the Secretary of Defense to ensure fifth generation aircraft such as the F-35, F-22, and B-21 can share and disseminate data collected by on-board sensors with other joint service users and platforms. This section would further require the Comptroller General of the United States to assess and provide an interim briefing to the congressional defense committees within 180 days after the date of the enactment of this Act, the Department’s doctrinal, organizational, and technological methods of managing sensor data collected by fifth generation aircraft and the ability of fifth generation aircraft to share information collected in real-time with other joint service users and platforms.

#### Section 220—Documentation Relating to Advanced Battle Management System

This section would require the Secretary of the Air Force to provide program documentation for the Advanced Battle Management System (ABMS) family of systems.

The fiscal year 2019 budget request for the Air Force cancelled the long-planned Joint Surveillance Target Attack Radar System recapitalization and included a small amount of funding in existing programs as a bridge to a new concept for comprehensive battle management command and control. The committee notes that this concept, the Advanced Battle Management System, envisions several existing airborne and ground intelligence, surveillance, and reconnaissance (ISR) and command and control systems connected by resilient, protected communications and data links.

The budget request provided limited programmatic details on ABMS. The committee is concerned with the lack of discernible benchmarks to assess and measure progress. The committee understands that the ABMS Analysis of Alternatives (AOA) will conclude in 2019. At that time, the committee expects the Air Force to complete the documentation requested by this section and submit it to the congressional defense committees not later than 180 days after completion of the AOA.

The committee also notes that Air Force modernization plans rely on introducing artificial intelligence and machine learning into a range of major weapon systems. Given the intended capability of ABMS, the committee believes the Air Force should consider prototyping and demonstrating the utility of artificial intelligence and automated sensor fusion as part of the ABMS concept.

#### Section 221—Documentation Relating to B-52 Commercial Engine Replacement Program

This section would limit funds for the B-52 commercial engine replacement program until the Secretary of the Air Force submits a capability development document and a signed test and evaluation master plan.

#### Section 222—Diversification of the Science, Technology, Research, and Engineering Workforce of the Department of Defense

This section would require the Secretary of Defense to assess critical skillsets required in the Department of Defense's science, technology, research, and engineering workforce to support emerging and future warfighter technologies, to include an analysis of the recruiting, retention and representation of minorities and women in the current workforce, and geographic diversity.

Additionally, this section would require the Secretary of Defense to develop and implement a plan to diversify and strengthen the Department's science, technology, research, and engineering workforce using existing programs and authorities to include authorities granted in sections 2304d, 2371, and 2358 of title 10, United States Code.

Finally, this section would require the Secretary to submit a report to the congressional defense committees within 1 year from the date of the enactment of this Act with the plan to diversify the workforce.

#### Section 223—Policy on the Talent Management of Digital Expertise and Software Professionals

This section would create a Chief Digital Engineering Recruitment and Management Officer at the Department of Defense re-

sponsible for promoting and maintaining digital expertise and software development as core competencies for civilian and military employees at the Department of Defense.

#### Section 224—Development and Implementation of Digital Engineering Capability and Automated Software Testing and Evaluation

This section would direct the Under Secretary of Defense for Research and Engineering and the Director, Operational Test and Evaluation, in consultation with Under Secretary of Defense for Acquisition and Sustainment, the military service acquisition executives, the service testing commands, and Defense Digital Service, to design, develop, and implement digital engineering capability and infrastructure to provide technically accurate digital models to the acquisition process that serve as the foundation for automated approaches to software testing and evaluation.

Additionally, this section would direct the Under Secretary and Director to carry out pilot programs to demonstrate whether it is possible for automated testing to satisfy developmental and operational test requirements to enable the Department to find and prevent defects in software earlier and deliver new capability to the field faster and on an iterative basis. This section would also direct the Under Secretary and Director to implement policies and guidance for both efforts and would require an initial report be submitted to the congressional defense committees outlining details on the selected pilot programs.

#### Section 225—Process to Align Policy Formulation and Emerging Technology Development

This section would direct the Secretary of Defense to establish a process to ensure that the policies of the Department of Defense relating to emerging technology are formulated and updated continuously as such technology is developed by the Department not later than 180 days after the date of the enactment of this Act. This section would also require the Secretary to submit a report on the process to the congressional defense committees.

The committee notes that technology development often outpaces policy formulation. For example, the Department is investing significantly in hypersonics, artificial intelligence, directed energy, and other cutting-edge technologies without a cohesive policy regarding development and employment of such capabilities, including the use of these technologies for offensive purposes. The committee believes the Department should better align policy formulation with technology development in order to promote responsible capability development and facilitate rapid and appropriate deployment to the warfighter.

#### Section 226—Limitation on Transition of Strategic Capabilities Office of the Department of Defense

This section would limit the ability of the Secretary of Defense to transfer the functions of the Strategic Capabilities Office to another organization or element of the Department unless certain conditions are met.

## SUBTITLE C—REPORTS AND OTHER MATTERS

Section 231—Master Plan for Implementation of Authorities  
Relating to Science and Technology Reinvention Laboratories

This section would require the Secretary of Defense, acting through the Under Secretary of Defense for Research and Engineering (USD(R&E)), to provide a master plan to the congressional defense committees by October 30, 2020, on how the Department of Defense will use its current authorities and responsibilities granted in previous National Defense Authorization Acts to modernize the workforce and capabilities of its science and technology reinvention laboratories. Further, this provision would require an initial report from USD(R&E) to be submitted to the congressional defense committees within 180 days after the date of the enactment of this Act on the barriers that prevent each military service from fully implementing currently available authorities and responsibilities. This section would direct the USD(R&E) to create the plan and report in consultation with the Secretary of each military department, the Service Acquisition Executives, and the affected commanders of each military command with responsibilities relating to research and engineering.

Section 232—Master Plan for Infrastructure Required to Support  
Research, Development, Test, and Evaluation Missions

This section would require the Secretary of Defense, in consultation with the Secretaries of the military departments, to develop and implement a master plan that addresses the research, development, test, and evaluation infrastructure and modernization requirements of the Department of Defense, to include the science and technology reinvention laboratories and the Major Range and Test Facility Bases. This section would require the master plan be provided to the congressional defense committees by October 30, 2020.

The committee is aware that the laboratories and test facilities do not compete well across the military departments for military construction and other infrastructure funding and that authorities provided to promote and allow for infrastructure investment remain underutilized by the Department. The committee expects the Department to utilize authorities provided by Congress to ensure the in-house infrastructure of the Department remains viable in order to continue to support warfighter requirements.

In developing the master plan, the committee expects the Secretary to enlist the expertise of the Under Secretary of Defense for Research and Engineering, the Under Secretary of Defense for Acquisition and Sustainment, and the Director of Operational Test and Evaluation. Finally, the committee expects the Secretaries of the military departments to enlist the expertise of their Service Acquisition Executives and civilian research leadership as well as the relevant commanders of each military command with responsibility for research and engineering.

#### Section 233—Strategy and Implementation Plan for Fifth Generation Information and Communications Technologies

This section would require the Secretary of Defense to develop and implement a strategy for fifth generation information and communications technologies not later than 270 days after the date of the enactment of this Act and to provide a briefing to the congressional defense committees not later than 180 days after the date of the enactment of this Act on progress in developing the strategy.

#### Section 234—Department-Wide Software Science and Technology Strategy

This section would require that the Secretary of Defense, acting through the Under Secretary of Defense for Research and Engineering, designate a senior official with principal responsibility for guiding the direction of research and development of next generation software and software intensive systems for the Department of Defense. Further, this section would require that the designated senior official develop a strategy for research and development of the next generation software and software intensive systems and submit the strategy to the congressional defense committees not later than 1 year after the date of the enactment of this Act.

#### Section 235—Artificial Intelligence Education Strategy

This section would require the Secretary of Defense to develop a strategy which identifies the key aspects, applications, and challenges associated with artificial intelligence that can be developed into an educational curriculum for military service members who utilize the technology in the execution of responsibilities. This section would also require the development of an implementation plan for the educational curriculum, and mandates that the Department of Defense provide the Artificial Intelligence Education Strategy and the associated implementation plan to the congressional defense committees not later than 270 days after the date of the enactment of this Act.

#### Section 236—Biannual Report on the Joint Artificial Intelligence Center

This section would require a biannual report by the Secretary of Defense on the Joint Artificial Intelligence Center (JAIC) and its efforts to harmonize the Department's work on artificial intelligence (AI) issues. The report would require the Department to detail the status of the JAIC, its current staffing, hiring efforts, and investment priorities. The report would specify how the JAIC is working with the military services, academia, industry, and international partners to develop and operationalize AI.

The committee supports the work of the Department of Defense on matters related to AI, as evident in section 238 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115–232), which directed the establishment of a set of activities within the Department of Defense to coordinate the efforts of the Department to develop, mature, and transition artificial intelligence technologies into operational use. The committee will ensure that the Department approaches issues involving AI, such

as workforce development and ethical use, in a substantive and comprehensive manner.

#### Section 237—Quarterly Updates on the Optionally Manned Fighting Vehicle Program

This section would require the Assistant Secretary of the Army for Acquisition, Logistics, and Technology to provide quarterly briefings, beginning October 1, 2019, to the congressional defense committees on the status and progress of the Optionally Manned Fighting Vehicle program.

#### Section 238—Grants for Civics Education Programs

This section would require that the Secretary of Defense carry out a program under which the Secretary makes grants to eligible entities, on a competitive basis, to support the development and evaluation of civics education programs.

#### Section 239—Technology and National Security Fellowship

This section would establish a Technology and National Security Fellowship program within the Department of Defense to increase national security professionals with science, technology, engineering, and math degrees.

#### Section 240—National Security Commission on Defense Research at Historically Black Colleges and Universities and Other Minority Institutions

This section would establish an independent Federal commission to advance the research capability of Historically Black Colleges and Universities and other Minority Institutions.

### TITLE III—OPERATION AND MAINTENANCE

#### ITEMS OF SPECIAL INTEREST

##### ENERGY ISSUES

#### Energy Efficiency Improvements for Shelters and Hard Containers

The committee notes that Department of Defense use of shelters, hard containers, and mobile units plays an integral role in overseas deployment. Many of these units are climate controlled in diverse and austere environments across the world in support of our Armed Services, often at great financial cost. The committee notes that use of shelters and hard containers requires cost avoidance, energy efficiency and sustainability.

Accordingly, the committee directs the Secretary of Defense to submit a report to the House Committee on Armed Services by February 1, 2020, on the development of energy efficient shelters and hard containers. At a minimum, the report shall contain the following:

(1) A discussion of the utility, viability, cost-effectiveness, and environmental benefit of energy efficiency improvements for shelters;