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HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON INTELLIGENCE,
EMERGING THREATS AND
CAPABILITIES
U.S. HOUSE OF REPRESENTATIVES

DEPARTMENT OF THE AIR FORCE

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Introduction

Chairman, Members of the Subcommittee and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2020 Air Force (AF) Science and Technology (S&T) Program and our efforts to innovatively and affordably respond to warfighter needs now, while simultaneously creating the force of the future.

Globalization and the proliferation of technology mean we face threats and competition across all domains. America's potential adversaries are rapidly fielding capabilities that approach our own. We must retain our technological edge and equip Airmen so they decisively prevail in combat across the full range of military operations. We are pushing the boundaries in new business practices and reshaping our approaches to deliver new, innovative technologies to the warfighter faster and smarter.

Global competition has changed the speed at which the world around us operates. We must be able to rapidly integrate new technology into our systems whether the development is internal to the Air Force or other parts of DoD, industry, or academia. The adversary and technology will constantly evolve, adapt and change. Today, the pace of change is accelerating; and we must adapt our processes and policies to move more rapidly ensuring our Airmen always have the advantage.

As the Air Force budget request highlights, we are committed to science and technology and driving innovation across the enterprise. The Air Force Fiscal Year 2020 President's Budget request for S&T is approximately $2.8 billion. This is an increase of $160 million, a 6.0% increase, from the Fiscal Year 2019 President's Budget request.

In addition to balanced S&T funding, the Air Force Fiscal Year 2020 President's Budget request also includes approximately $1.6B in prototyping and experimentation funding focused on moving S&T out of laboratory and into the hands of warfighters to build capability at the speed of innovation (i.e. Advanced Engine Transition Program, hypersonics prototyping, directed energy

prototyping, and other smaller developmental prototyping activities).

The Air Force Fiscal Year 2020 President's Budget request for S&T, prototyping and experimentation sets us on a path to be responsive to emerging S&T worldwide, apply new scientific breakthroughs to Air Force problems, embrace agility in focusing limited resources into areas of highest potential impact and rapidly translate technical breakthroughs into fielded Air Force capabilities.

Global Persistent Awareness and Resilient Information Sharing

Many technologies will contribute toward improved capabilities for Global Persistent Awareness and Resilient Information Sharing, but I will highlight our focus on quantum, cyber, and space technologies.

Quantum and Advanced Communications

The Air Force focuses investment in quantum information science (QIS) in three specific areas: quantum sensing (sensors and clocks used for navigation, detection, and force orchestration), quantum communications (advanced, secure, tamper-evident communications and networking enabled by fundamental quantum effects), and quantum computing (storage devices, specialized circuits, and algorithms operating on data maintained in superposition). While the current Air Force S&T goals in advanced quantum communications and quantum computing are more far-term, all three QIS areas (sensing, communications and computing) are expected to have long-term, large scale impacts. For example, QIS will modernize our nuclear forces, improve Command Control Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR) as well as resilient and agile logistics. This commitment will also lead to better joint lethality, especially in contested environments, improved materials performance from fuels to avionics to airframes, and finally, to more advanced autonomous systems.

Cyber and Big Data Analytics

Every day, Airmen encounter sophisticated and persistent adversaries in cyberspace, some of whom are now peer competitors in this domain. The Air Force S&T cyber investment touches many areas. We use cyber to assure communications across physical and security domains, to protect our legacy and future avionics systems, to counter global threats to mission performance (spectrum congestion and jamming), to increase air-to-air capacity over longer range with military-grade security, and to expand available bandwidth through dynamic spectrum access. The Air Force is enhancing cyber resiliency through an effective mix of redundancy, diversity, and distributed functionality that leverages advances in virtualization and cloud technologies. Efforts such as the Cyber Grand Challenge, executed in collaboration with DARPA, have informed Air Force investments in counter cyber operations such as defensive autonomic response. The Air Force boosts mission assurance with S&T efforts that pursue survivability and freedom of action in contested and denied environments through enhanced cyber situational awareness for air, space, and cyber commanders.

This past year, the Air Force in partnership with DARPA participated in the planning, commitment, and creation of a technology repository for a U.S.-based Center of Excellence supporting a hardened microkernel that protects critical assets, enhances mission assurance, and eliminates some classes of cyber-attack. The kick-off Summit with industry and academia in November 2018 committed itself to the goals of removing barriers to adoption.

Additionally, the Air Force is leveraging Big Data technology, to provide analytic capabilities across multiple modes of intelligence, including virtualization distributed computing and machine learning to achieve operational agility through superior decision speed. We are developing prototypes of expandable cloud processing analytic capability that combine signals intelligence and Moving Target Indicator radar data, and can incorporate other data sources. The prototypes enable instant look-back for analysts through fast processing of large

amounts of fused data.

Space

Our adversaries have recognized the advantages we gain from operating in space, and are developing capabilities to deny us the use of space in crisis or war. While we all would prefer the space domain remain free of conflict, our adversaries are not operating in a manner aligned with that preference. We will deter and defeat these threats in order to secure the satellite constellations that power our military forces and civilian infrastructure.

The Air Force's S&T portfolio aligned to space is broad in scope, creating a very agile portfolio spanning basic research published in world renowned scientific journals to in-house satellite operations conducted on satellites assembled by laboratory Airmen. The Air Force Space S&T portfolio covers the breadth of Air Force interests by investing in foundational research and space experiments, as well as emphasizing the five specific disciplines of Space Environment, Nuclear Deterrence Operations, Space Situational Awareness, Communication/Position, Navigation and Timing, and Intelligence, Surveillance, and Reconnaissance/Missile Warning.

The Air Force seeks to explore and mature a number of space resilience technologies in a relevant environment through on-orbit space experimentation. The Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) Augmented GEO Laboratory Experiment (EAGLE) project, launched on 14 April, is currently demonstrating enhanced capabilities in space system anomaly resolution and the capability to supplement ground based space situational awareness assets from a geosynchronous platform. Through this experimentation, Air Force Space Command operators are learning new operational tactics and techniques that will inform future requirements for delivering space systems to the warfighter.

The Air Force also continues development of the Navigation Technology Satellite-3 (NTS-3), which aims to demonstrate a range of technologies for potential inclusion in future GPS

satellites or potential augmentation of GPS, such as hosted Satellite Navigation (SatNav) payloads on other DoD, commercial, or international spacecraft. Launch of NTS-3 is currently projected for 2022 with a planned one-year, on-orbit experiment period.

Rapid, Effective Decision-Making and Complexity, Unpredictability, and Mass

Autonomy, Artificial Intelligence, and Robotics

The Air Force held an Artificial Intelligence Summit and identified three key investment areas: condition based maintenance; supporting the intelligence community; and autonomous air combat operations. Advances in these areas provide significant improvements to decision-making speed and mission agility, posing new challenges to the adversary at a pace they cannot match.

The Air Force is focused on operationalizing autonomy on two fronts; autonomy at rest and autonomy in motion. Autonomy at rest provides tools to move inside the adversary decision cycle by accelerating the intelligence process and providing predictive logistics and maintenance. The focus of the autonomy in motion thrust is the reduction of operator burden and increased performance striving to overwhelm our adversaries with complexity and speed.

The advent of Unmanned Air Systems (UAS) introduced a new class of air platforms and enabled an unrivaled ability to provide ISR on the battlefield. The Air Force is poised to take UAS to the next level with digital engineering and low-cost manufacturing, providing a flexible, adaptable, and cost-imposing capability to the warfighter. On March 5, 2019, the Low Cost Attritable Strike Demonstration effort (XQ-58A) completed a successful first flight test on 5 Mar 19 in Yuma, CA. The launch and recovery systems worked as expected and the vehicle flew for 72 min. For this test, the remote pilot controlled the aircraft in semiautonomous manner by providing inputs but allowing the aircraft to self-manage stability and control. This was the first step

of our Skyborg effort, which advances research in aircraft piloted by artificial intelligence. We are now ready for the second step toward unmanned tactical aircraft where we need to think of the aircraft not as just an air platform but also as a software platform, which could allow a future of flying with an artificially intelligent wingman. These aircraft could be used in a more dangerous role or react more quickly to a threat faster than our current exquisite manned aircraft. These attritable aircraft can be used to impose high-cost responses from our adversaries and extend mission range. There are some tough challenges ahead but we need be the first to develop this technology or we run the risk of falling behind. We need to accelerate ahead of the pack.

The future aerospace manufacturing environment will feature flexible and reconfigurable robotic systems that work in close proximity with the human workforce. The Air Force successfully demonstrated the Advanced Automation for Agile Aerospace Applications (A5) Robotic System. Typically, robotic arms are bolted into place and perform repetitive actions as a platform moves down a production line. The A5 robot is mounted on a mobile platform that allows it to move about an aircraft. The 22,000 pound A5 robotic system is the first multi-purpose robot designed for use on an aerospace factory floor. By capitalizing on advancements in man-machine interfacing technologies, the A5 robot is anticipated to cut depot maintenance times for aircraft coating removal up to 50 percent, saving time and money over the lifecycle of a platform.

Disruption and Lethality

Hypersonics

We are assessing our technology investments to ensure our future warfighters can be more disruptive and lethal. Capitalizing on recent years of increased investment, the Air Force is deliberately accelerating the pace of research and development across the breadth of hypersonic regimes and systems and directed energy efforts.

The Air Force, in partnership with the DARPA, is maturing two S&T flight demonstration programs. The Hypersonic Air-breathing Weapon Concept (HAWC) activity matures and integrates critical technologies and attributes of an effective air-launched, scramjet-powered hypersonic cruise missile capability. Similarly, the Tactical Boost Glide (TBG) effort develops and demonstrates technologies to support air-launched, deep-strike hypersonic boost-glide systems. In addition, the Air Force maintains a comprehensive and wide-reaching investment portfolio associated with hypersonic technology, including propulsion, advanced materials, manufacturing technology, sensors and algorithms, and aero-structures.

The Air Force is pushing to field air-launched hypersonic strike capability as soon as possible. Thanks to the Middle Tier Acquisition authority granted to the Air Force by this Congress (Section 804 of the FY16 National Defense Authorization Act), we have been able to race down the path to this capability even faster through two prototyping efforts. The AGM-183A Air Launched Rapid Response Weapon (ARRW, "Arrow") will operationalize the technical concepts established by the Air Force Research Laboratory and DARPA partnership in hypersonics S&T. Likewise, the Hypersonic Conventional Strike Weapon (HCSW, "Hacksaw") is integrating separate, more mature technologies into a new configuration for air-launched prompt strike. The Services have signed a Memorandum of Agreement so all of the Department's hypersonics technologies can be leveraged to move as fast as possible to capability. Stripping a total of 10 years from these programs, we expect to demonstrate the Department's first operational flight test in 2020 and achieve early operational capability in 2021.

Directed Energy

Exploiting directed energy technology, high energy laser (HEL) and high-powered microwave (HPM), allows us to fundamentally alter operational concepts and maintain parity with peer competitors, especially as we face operating in increasingly contested environments. Directed energy

weapons offer transformational capabilities to enable Airmen to effectively, affordably, and rapidly defeat massed attacks from an adversary and to strike critical targets at the speed of light. These same weapons can provide the ability to disruptively engage targets of interest with little to no collateral impacts or detectable disturbance and provide protection to Air Force assets that must operate in harm's way.

The Air Force has a long history of science and technology investments in directed energy to the point that we are now positioned to provide the airman distinctive and revolutionary capabilities for several Air Force and joint mission areas. The Air Force Directed Energy Weapons Flight Plan identified three use cases for directed energy weapons: base defense, precision engagement, and aircraft protection.

We see the most near-term application and potential transition of directed energy weapons for the base defense mission area. In October 2018, the Air Force held a successful experimentation event at White Sands Missile Range, NM. The experiment focused on understanding the capabilities and limitations offered by existing off-the-shelf directed energy HPM and HEL systems against unmanned aerial systems (UAS). Building on the success of this counter-UAS directed energy experiment, the Air Force plans to conduct further experiments with directed energy technologies for base defense. Through directed energy prototyping and experimentation the Air Force expects to learn operational tactics and techniques over the next 18 months that will inform future requirements for delivering directed energy systems to the warfighter.

The Air Force is continuing S&T efforts for the precision engagement and aircraft protection use cases to enable future prototyping and experimentation in these mission areas.

Biotechnology

Biotechnology research is also part of the S&T portfolio. For example, we are continuing to develop bio- and nature-inspired designs to improve the functionality and efficiency of weapon seeker

and sensor concepts, developing multi-faceted wide-field-of-view seekers for use in next-generation weapon concepts such as the Miniature Self Defense Munition. Additionally, biotechnology research on biomarkers recently transitioned to the Air Logistics Center at Warner Robbins AFB that detects stress and exhaustion for workers in confined space areas. The Air Force also conducts directed energy bioeffects research at Joint Base San Antonio, TX. Our research focuses on the interaction of lasers and radio frequency energy with the body to understand harm, protect the Airman, and exploit vulnerabilities for directed energy weapons.

Initiatives to Field Tomorrow's Air Force Faster and Smarter

Innovation Outreach

Technology is evolving ever more rapidly, and is being driven primarily by the private sector. Air Force leadership understands the importance of connecting innovators of disruptive technologies with our warfighters for capability development. The Air Force is developing an ecosystem which serves as a catalyst for innovation and agile engagement across industry, academia and non-traditional contributors.

The Air Force Small Business Innovation Research (SBIR) / Small Business Technology Transfer (STTR) Program provided undiluted capital as a means of leveling the playing field for small business involved in research, development, testing and evaluation of cutting-edge technologies and systems. We implemented several experimental processes designed to reduce the time to contract, increase exposure of the opportunity for technology relevance and to reduce time of technology transition.

Air Force Pitch Day completed a successful event on 6-7 March 2019 in New York City. Our team of "venture ninjas" awarded 51 contracts to startups and small businesses on-site, with initial payments made in less than 15 minutes. The fastest was done in three! Solicitation timeline was cut from 180 days to less than a week, and 242 contracts, worth $75M, were awarded that week. We

saw a wide array of ideas: companies building downlink hotspot satellites in space, others applying AI to imagery to find targets of interest, others turning that imagery into 3D maps with all sorts of applications. With game-changing ideas being generated in commercial startups at an increasingly accelerating pace, we can ill afford the next generation of tech companies to grow up disconnected to our mission. Expect more Pitch Days in future.

A large part of Pitch Day's success was AFWERX, an innovation outreach program with the goal of improving Air Force capabilities by connecting innovators, simplifying technology transfer, accelerating results and fostering a culture of innovation in Airmen. AFWERX has several tools at their disposal to connect Airmen ideation with cutting edge companies by using accelerators, public challenge events, and access to capital through the SBIR program. Additionally, they have created a virtual collaboration tool for enterprise-wide use, including for use with this year's Squadron Innovation Fund campaign. To further facilitate the transformation of ideas-into-solutions, AFWERX has opened 3 innovation hubs in Las Vegas, Crystal City and Austin. These centers work together to provide tech scanning, industry analysis, light prototyping with basic manufacturing tools, and lean start up designing. The hubs also connect the Air Force with high-tech entrepreneurs and spare-time garage tinkerers, who use the AFWERX processes as a way to pitch their ideas to the Service.

Ensuring success of startups, who are developing technologies of importance to the warfighter, is also an important part of the Air Force innovation outreach efforts. In 2018, the Air Force partnered with Techstars, a company that assists with the acceleration of innovative startup companies, to launch The Air Force Accelerator Powered by Techstars. The tech accelerator focused on increasing the engagement with early stage innovative startups to tackle Service needs. It signaled the Air Force was open for business and in a way that resonated with the entrepreneurial community. The initial program was successful, resulting in all 10 cutting-edge

companies winning DoD contracts or private investment. This is another example of how the Air Force is creatively adapting existing business enterprise tools to connect with non-traditional partners.

Sustainment Research and Development

The 2018 National Defense Strategy called for the application of modern technology to reduce sustainment costs while improving aircraft availability. In response, the Secretary of the Air Force, established the Rapid Sustainment Office (RSO) to identify, apply, and scale game-changing technology to decrease sustainment costs and increase readiness across the enterprise.

The Air Force continues to experience product support challenges with its aging aircraft fleet due to the rising number of Diminishing Manufacturing Sources and Material Shortages (DMSMS) for parts and support equipment. To address this problem, the RSO is strategically poised to accelerate implementation of agile technology capabilities, such as Additive Manufacturing (AM), Condition-Based Maintenance and Automation/Laser technologies to address the Service's part supply challenges.

Advanced Manufacturing

The Air Force's Manufacturing Technology program is a key enabler of Executive Order 13806 (Jul 2017) mandating the United States strengthen the manufacturing capacity of the defense industrial base, and increase the resiliency of supply chains critical to national security. The Air Force is focused on developing and deploying agile aerospace manufacturing and sustainment technologies in accordance with the SECAF's vision of Fielding Tomorrow's Air Force Faster and Smarter. Through engagement with the other Services and industry, the Air Force's Manufacturing Technology program is advancing the state-of-the-art in aerospace manufacturing in

critical areas such as hypersonic strike, networked command, control and communication (C3) systems, attritable and low-cost aircraft and space systems, while developing new efforts aimed at bolstering the nascent industrial base in directed energy weapons and quantum devices. The agile manufacturing vision is premised on implementing advanced digital manufacturing capabilities within the industrial base through three strategic thrusts: 1) implementing the factory of the future to drive greater efficiencies through human-machine teaming, Industrial Internet of Things (IIoT) systems, and augmented/virtual reality tools; 2) creating a digital engineering and design environment to deliver comprehensive life cycle data management as well as advanced cost and supply chain management tools; and 3) enabling greater implementation of additive manufacturing technology for both next generation capabilities as well as the rapid fabrication of parts and tooling for sustainment operations.

A recent success in this effort is the Air Force-trademarked AgilePod®. It is a multi-sensor capable and flight-line reconfigurable pod that enables operators in the intelligence, surveillance and reconnaissance (ISR) and Air Force Special Operations communities to rapidly configure the pod to accommodate mission requirements. Additionally, the pod is platform agnostic and enables the rapid integration of new capabilities.

Digital Engineering

The Air Force engineering enterprise has been exceptionally capable at providing the technical foundation to deliver advanced weapon systems. Acquirers must be more agile and innovative to rapidly adopt decisive technologies and deliver on shorter acquisition cycle times. The Air Force strongly supports the Digital Enterprise Environment (DEE) as a critical modernization initiative that benefits the warfighter by reducing engineering decision making timelines for fielded systems, thus increasing weapon system availability, and allowing more robust decision making during system design. The modern, integrated, model-based DEE will enable the Air Force to convert

its acquisition processes from traditional industrial age ways of doing business to a new streamlined approach that rapidly develops, fields and sustains new capabilities.

Recently, a few Air Force programs implemented a portion of this capability and have seen dramatic reductions in decision-making timelines. For example, A-10 engineers used digital models to develop the repair process following a bird strike to the wing. The model was constructed to fit over the damaged area to create a part that would fit the wing area. This method allowed the engineers and machinists to inspect the damaged structure and the proposed repair digitally before beginning fabrication. These Airmen produced a repair part so precise that squadron aircraft mechanics mounted the part without any additional adjustments.

Supporting Innovation – People, Infrastructure and Authorities

We recognize the technological superiority of the Air Force depends on the talent and innovative spirit of our workforce. The ability to recruit, retain and develop the Air Force science, technology, engineering and mathematics (STEM) workforce has been greatly supported and enabled by Congress. The National Defense Authorization Acts of the past several years have provided additional personnel authorities to the S&T community. In order to stay competitive, we have utilized the direct hire authorities to gain approximately 150 personnel from Academia and Industry. The authority also allows us the ability to attract the right talent for the right positions, which is vital to our innovation ecosystem. We recognize that we are in competition for the right talent, and we must develop processes and policies to recruit, hire, and retain top talent as our people are our foundation. By using the competition smartly, we can set the requirements high to attract quality talent. We are continuing our efforts to fully implement all of the personnel authorities provided by the Congress.

Infrastructure focused on S&T is an important component to support innovation and force modernization. While our researchers routinely partner with academia and industry, a significant portion of military-focused research is done in Air Force facilities. We continuously assess laboratory

infrastructure to determine how best to support technology needs of the future. With the latest release of the National Defense Strategy, we implemented a multidisciplinary/cross-organizational team to confirm and validate alignment of a 5-year infrastructure and facility plan. Results are expected later this summer.

Conclusion

The Air Force's Science and Technology Portfolio is shaped to deliver, with speed, capabilities that are lethal, persistent, resilient and unpredictable and cost-imposing for our adversaries. While the technologies the Air Force invests in are critically important, the pace at which the Air Force innovates and responds is even more significant. We are pushing the envelope on getting technology to the warfighter faster and smarter by transforming our innovative culture, creating new industry, academia and international partners, and utilizing new business and hiring processes, and improving the way we develop and transition technology.