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THE UNITED STATES HOUSE ARMED SERVICES COMMITTEE

IMPLEMENTATION OF THE DEPARTMENT OF THE AIR FORCE SCIENCE AND TECHNOLOGY STRATEGY, POLICY, AND PROGRAMS

Department of the Air Force
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Armed Services Committee
of the United States House
Subcommittee on
Cyber, Innovative Technologies, and Information Systems

Statement of:

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Chairman Langevin, Ranking Member Banks, and distinguished Members of the subcommittee, thank you for the opportunity to provide testimony on the Fiscal Year 2023 President's Budget Request. The Department of the Air Force (DAF) Science and Technology (S&T) Strategy continues our efforts to respond to the warfighter faster, while simultaneously developing the future force.

As the nature and sources of conflict have become more diverse and less predictable, our nation continues to face a complex set of current and future security challenges, including the resurgence of great power competition from China and Russia. The rapid proliferation of global technology means the speed at which we change must increase. As the 2022 National Defense Strategy emphasizes, we must build enduring advantages for the future Joint Force, which includes getting the technology we need more quickly. It is clear that supremacy in the air and space domains can no longer be presumed without deliberate technology investments, modernization of our military systems leveraging innovation and partnerships across the broader ecosystem, and growing the talent, skills and diversity necessary to deliver the critical operational capabilities and functions necessary for enduring competitive advantage.

Accelerating Force Development with Technology

Transformational S&T Investment Component

The Department of the Air Force S&T portfolio provides broad-based, enabling and enduring investments addressing near-, mid-, and far-term capabilities, and a focused transformational component that matures game changing technologies for transition.

The transformational component is focused on developing leap-ahead capabilities, fueled by emergent technology but pursued with a system-of-systems construct, and executed with focus, urgency, and analysis-driven investment decisions. It is differentiated in being driven by future force design, cross-disciplinary competition & partnerships, and overseen by an Executive Committee (EXCOM) of DAF requirements and acquisition leaders. The intent is to align twenty percent of the DAF S&T annual budget to the transformational component.

Now in its third year, our process to identify, prioritize, and govern the transformational component investments is demonstrating significant value. The DAF Warfighter Technologist (WARTECH) process engages with warfighters and technologists to collectively ideate and jointly mature transformational component proposals that address strategic capability needs of both the Air Force and Space Force. These needs also inform new competitive 6.2 applied research budget activity transformational investments to ensure a continuous pipeline of ideas. Two programs: “Seedlings for Disruptive Capabilities” and “Explore” each pursue high risk areas of the Air Force and Space Force future capability needs and drive emerging technology investments and partnerships that contribute to transformational solutions. Since the Transformation Capabilities Office (TCO) began in September 2020, we have competitively sourced over 500 proposals from internal and external performers through Explore & Seedling campaigns.

To date, the Transformational Component EXCOM has approved over two dozen WARTECH Strategic 6.3 Investment (S6I) projects, and now oversees four multidisciplinary Vanguards. As these disruptive “first in class” technology applications mature, complementary experimentation and prototyping investments carry out necessary concept analysis and refinement work to enable transition into programs of record. These multi-budget activity efforts

bring to bear warfighting capability that otherwise could not be achieved in accelerated timelines, providing transformative capabilities to the DAF for years to come.

Vanguard Programs

Within the transformational component portfolio are a select number of premier programs, for which the TCO is best known. These programs are commissioned as "Vanguards" and have succeeded in representing a new model for accelerating the pace of transitioning solutions. Program Executive Officers (PEO) are designated upfront to develop and execute an acquisition strategy, in collaboration with the Air Force Research Laboratory (AFRL) Vanguard manager. With the addition of Rocket Cargo in 2021, there are now four active Vanguard programs with three to transition by the end of FY23: Skyborg, Navigation Technology Satellite-III (NTS-3), and Golden Horde.

Rocket Cargo will leverage and influence commercial investments to deliver 30-100 tons of cargo anywhere on the planet within tactical timelines. This Vanguard is seeking to provide a responsive transport mode for U.S. Transportation Command's (TRANSCOM) Urgent Resupply Mission. Rocket Cargo will enable the capability of future commercial rocket technology for defense, demonstrating capability through three use cases; point-to-point, austere landing, or airdrop. A small DAF S&T investment today influences early commercial design efforts and leverages $5-10B ongoing industry and NASA investments.

The Skyborg Vanguard demonstrates an Autonomy Core System (ACS), its portability into different low cost attritable aircraft platforms, and demonstration of autonomy in multiple missions. Built though modular open architecture design, digital tools, and rapid software development, Skyborg demonstrates an innovative way to generate combat power as a force multiplier, enhance forward force posture, and provide low cost combat mass. With the first

large scale flight test of an ACS last May, Skyborg's "first of its kind" open, portable, and modular architecture has already heralded in a new era of autonomous capability to the DAF.

The NTS-3 Vanguard is developing advanced techniques and technologies to detect and mitigate interference to positioning, navigation, and timing (PNT) capabilities and is increasing satellite navigation (SATNAV) resiliency for military, civil, and commercial users. To date, the Vanguard has successfully completed software implementation of the first advanced SATNAV signal in the NTS-3 experimental receivers. In partnership with industry, NTS-3 has entered its manufacturing and test phase and is building components that will create the reprogrammable and modular SATNAV payload and flexible phased array antenna system that will broadcast high-power signals during the on-orbit demonstration. With the capability NTS-3 provides, mission success depends not on GPS signals in a highly contested environment, but instead, tailorable software-defined high-power, anti-jam/spoof, PNT signals adapt to real time regional threats to enable mission success. NTS-3 launch is slated for Fiscal Year 2023.

The Golden Horde Vanguard demonstrates networked collaborative and autonomous (NCA) technology for weapon systems. Networked collaborative weapons share data, interact, and develop and execute coordinated actions or behaviors across an entire group of weapons to increase survivability and lethality. It will also deliver a digital ecosystem for technology maturation, integration, and validation of advanced weapon behaviors known as the Golden Horde Colosseum. The Colosseum increases industrial base engagement, lowering entry barriers, and providing a "sandbox" for traditional and non-traditional entrants to enable rapid development and demonstration of new NCA technologies. This approach will cultivate competition, and provide quicker and transition on-ramps.

Improving Technology Transition

Prototyping and Experimentation

Rapid transition of emerging technologies is imperative to ensuring the DAF maintains advantage over pacing challenges and acute threats. Technology transition investments, including prototyping, experimentation, and development planning, provide critical insights into operational utility and technical feasibility of a new warfighting concept; perform concept refinement and risk reduction; and inform appropriate acquisition pathways. The DAF Strategic Development Planning and Experimentation (SDPE) office, strategically located within AFRL, executes these prototyping and experimentation activities. These technology transition investments are focused on the most significant operational needs identified by senior DAF leadership, Space Force Futures & Integration, and Air Force Futures.

A few examples will help illustrate the impact of our current prototyping and experimentation work. Global Lightning is empirically testing the operational utility and competitive advantages of using commercial space-based internet to deliver robust data rates and low latency communications to support tactical missions, interoperable with traditional military communications. Global Lightning is testing this capability with several platforms (AC-130, KC-135, and F-35) and rapidly deployable ground terminals. Global Lightning's success has already resulted in five transitions into programs of record, with initial capabilities on track for fielding in 2023. Global Lightning is also a great example of joint cooperation, and has featured testing events with Army, Navy, Defense Advanced Research Projects Agency (DARPA), U.S. Northern Command (USNORTHCOM), Air Combat Command, and other partners.

Another technology transition exemplar is the Rapid Dragon palletized munitions prototype designed to support cargo aircraft to deploy long-range munitions. A successful

demonstration of this system in December 2021 combined a missile armed with a live warhead and three mass weapon simulants deployed from an MC-130J flown by Air Force Special Operations Command. The test demonstrated safe separation and weapon deconfliction, positive aerodynamic control, engine ignition, powered maneuvering and destruction of the target.

Rapid Defense Experimentation Reserve (RDER)

The RDER program is administered by the Office of the Secretary of Defense. RDER provides opportunity to accelerate defense innovation and modernization by incentivizing multi-component coordination and cooperation toward the development of joint capabilities supporting the Joint Warfighting Concept (JWC). DAF leverages the RDER program to augment S&T concepts, technology development, prototyping, and experimentation activities to address joint needs. In FY23, the DAF plans to execute a number of priority RDER experiments with Service and Agency partners, and has additional proposals identified for FY24.

Development Planning

Development planning is a key enabler of technology transition to support DAF Operational Imperatives (OIs). The OIs are the critical operational capabilities and functions the Department of the Air Force must invest in to protect the United States' ability to deter conflict and project power against pacing challenges. Development planning consists of the vital concept refinement and engineering and integrated modeling and analysis activities that enable transition of technology to programs of record. Outcomes of these development planning activities include technologically informed requirements; mature concepts that are technically feasible, operationally relevant, and militarily useful; and recommendations for science and technology investment to reduce technical risks. A Capability Development (CD) Summit, established in 2021, convened to converge requirements, acquisition, and resourcing leadership and align these

departmental planning processes on DAF priorities. The CD Summit meets throughout the year to prioritize and oversee capability development planning activities and investments toward OI shortfalls and opportunities.

Operational outcomes are achieved not only through accelerating technology transition and development of individual systems, but from the integration of systems and families of systems into capabilities. A modular, open systems architecture approach enables scalability, flexibility, and interoperability necessary to adapt and upgrade components, systems, platforms, and systems-of-systems quickly in response to threats or opportunities as technological advances are made. Air Force and Space Force staffs, Program Executive Offices, Major Commands, and Deltas are building and leveraging a collaborative digital environment, reference architectures, and standards to facilitate this approach.

Deepening and Expanding the S&T Enterprise

In Fiscal Year 2021, the DAF expanded and strengthened its partnerships, drawing technology and innovation from universities, defense and commercial industry, allied partner nations, and other government organizations.

Partnerships

Leading in innovative partnerships, AFWERX continues to transform the way we work with commercial companies. In late 2021, DAF launched SpaceWERX, our newest innovation arm, focused on pursuing novel technologies for the Space Force. SpaceWERX is an organic part of AFWERX, leveraging shared processes and resources.

AFWERX continues to spearhead initiatives to lower barriers for commercial tech companies to enter into the defense market. In 2021, the AFVentures program awarded 1,893

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts worth a total of $1B supporting requirements across all MAJCOMs. More than 75% of AFVentures small businesses are new performers to the DAF. Since 2018, AFVentures awards have led to $2.2B in follow on in follow-on private funding (e.g., Venture Capital) and $1.4B in follow-on, non-SBIR Federal contracts, a 5.6-to-1 return for the DAF.

AFWERX Prime expands technology transition pathways by accelerating emerging dual-use markets with government and commercial co-investment. The first Prime program, Agility Prime, is a collaborative initiative creating revolutionary military airpower concepts. Through co-investment with commercial technologists Agility Prime is accelerating the transformative vertical flight market. In FY23 Agility Prime plans to award a procurement or lease contract for 12 aircraft for early operational evaluation. We appreciate the support of Congress on this effort, including the additional $54 million appropriated for Fiscal Year 2022. In late 2021, SpaceWERX announced an Orbital Prime initiative that will seek to accelerate emerging dual-use markets for active debris remediation and capabilities such as on-orbit servicing, assembly, and manufacturing.

International partnerships

International partnerships are a critical accelerator of innovation, and the DAF continues to work with partner nations to collaboratively develop and adopt game-changing technologies. Working in alignment with the framework established in the DoD International Science and Technology Strategy, we seek to leverage our combined investments to retain technological superiority and achieve our defense objectives, by delivering valuable S&T outcomes.

In Fiscal Year 2021, DAF subject matter experts were involved in over 235 activities and technical interchanges, scientist exchange programs, and events with North Atlantic Treaty

Organization (NATO), The Technical Cooperation Program (TTCP), allies, and partner nations. Currently, over $90.6M of DAF S&T is associated with international partner agreements and grants across multiple nations. These partnerships align strategically with DoD critical technology areas and DAF capability priorities, and enhance our awareness of innovative solutions in emerging international markets. International S&T collaboration not only leverages shared expertise and investment, but grows foundations of trust that strengthen these important relationships.

Research and Tech Protection

Preserving our technological advantage requires a comprehensive approach that fosters technology development, integration, and fielding, while protecting critical mission capabilities and technologies against unwanted transfer or interference, without discouraging the participation of the talent and partners that we wish to attract and engage. Open collaborations are critical to the DoD, yet we must protect against those who would seek to exploit the openness that is the basis for our innovation potential, economic strength, and national security of the U.S. We must uphold our fundamental principles of integrity, openness, reciprocity, merit-based competition, and transparency. This requires alignment across the DoD and our Agency partners, the defense and commercial industrial base, academia, and equally important, our international allies and partners.

The DAF acquisition, technology, and intelligence stakeholders are collaborating to improve threat awareness, inform process controls, train and educate our workforce, and implement best practices and standards. We are an active participant in an OSD-led research protection group comprising Services and Defense Agencies to implement research and tech protection in accordance with the Presidential Memorandum on United States Government-

Supported Research and Development National Security Policy (i.e., the NSPM-33). In 2021 DAF initiated pilots with the application of open source analysis to examine risks associated with research grants, including conflict of interest and conflict of commitment. These efforts are guiding policy and processes for critical technology protection.

Science and Engineering Capacity for Strategic Competition

Organic talent and technical expertise is equally critical to national defense as the investment in our warfighting systems and technologies. In 2021, with direction from the Secretary of the Air Force, we renewed assessment of the posture and capacity of the DAF science and engineering (S&E) workforce. This effort leverages previous work implementing the DAF S&T 2030 Strategy as well as internal and external panels of industry, academia, and government expertise. Resulting data and assessments document civilian and military S&E workforce demographics, and associated recommendations for continued monitoring of S&E workforce health metrics, strengthening the S&E workforce, and addressing DAF-unique talent needs.

The competition for the best talent drives us to focus our processes and policies to recruit, hire, and retain top talent. We are appreciative that the National Defense Authorization Acts of the past several years have provided additional personnel authorities to the S&T community. In particular, the Science and Technology Reinvention Laboratory (STRL) Direct Hire Authority (DHA) flexibilities allow us to quickly hire and use executive headhunter recruitment firms for hard-to-fill senior leader positions. With these authorities we have been able to fill over twenty Air Force positions with top-notch talent in cutting-edge areas, including Communications and Networking, Modeling Simulation and Analysis, Microelectronics, Data Analytics, and Autonomy. Maintaining our advantage also requires hiring technology leaders at industry-

comparable speeds. The AFRL has expedited hiring timelines, and also expanded the use of many flexible personnel management authorities, to include more use of telework options and alternate work schedules.

DAF values the strategic advantage that diversity in our workforce brings to our mission. The Air Force Historically Black Colleges & Universities and Minority Serving Institutions (AF HBCU/MSI) Outreach Initiative strengthens the Air Force Small Business Innovation Research and Small Business Technology Transfer programs. This initiative is a $97M+ effort reaching out to HBCUs and MSIs with an opportunity to apply for funding of research and development through strategic partnerships with small businesses. In Fiscal Year 2021, partnerships were formed with 19 HBCUs that are now an integral part of the outreach initiative.

Science, Technology, Engineering, and Math (STEM) K-12 outreach is also an important component to building the workforce of the future. The DAF conducts more than 3,000 STEM outreach events per year, leveraging local, state, and federal organizations to reach nearly 393,000 students and teachers across the country. This outreach allows us to attract students to possible DAF careers. To create a more cohesive STEM ecosystem-focused program, the Air Force K-12 STEM Team is engaging in a three-year strategic plan initiative focusing on a holistic education framework for creating both local and national STEM experiences. Our goal is to create a bridge between current K-12 STEM outreach efforts and undergraduate/graduate internship and scholarship programs that will promote increased diversity and inclusion in the future DoD talent pool.

A highlight of our STEM portfolio is the Leadership Experience Growing Apprenticeships Committed to Youth (LEGACY) program that identifies and retains young,

diverse talent for the future workforce. The phases of LEGACY are Craftsman (age 11-15), Jr Apprentice (age 16-18), and Apprentice (college). Craftsman students are inspired through week-long camps with hands-on experiences and opportunities. Jr Apprentice students experience a six to eight week internship where they work under a mentor. Apprentice students build on their experience from the Jr Apprentice phase; they are expected to be more independent and have more responsibility. Ultimately, LEGACY aims to introduce students to STEM at a young age, continue to grow the STEM interest, and eventually hire students into a STEM-driven Air Force career. In 2021, 388 students participated in LEGACY with a return rate of 84%.

Digital Transformation

The DAF recognizes the opportunity for achieving a rapid increase in new military capability through a digital acquisition backbone. Digital transformation is changing the means by which we develop, acquire, and field disruptive technologies and is providing digital skills and tools to our workforce. The DAF is advancing three transformation imperatives:

1. Enable capabilities to operate in integrated, cross-organizational, virtual environments in which government, industry, and academic partners can share data.
2. Apply smart coding and containerization to bring automation and secure functionality to developers and end users.
3. Implement digital model based development, testing, and lifecycle sustainment practices to identify issues earlier, iterate faster, and optimize solutions in a safe, and more affordable, virtual environment.

This transformation is built upon digital engineering, agile software development, and open systems architecture. However, workforce and cultural transformation are at the core of our

digital transformation. In the past year, the DAF has partnered STEM institutions to generate research and internship programs that provide real-world projects to develop the digital skills needed in our future workforce; invested in advanced model-based engineering and product lifecycle management training, tools, and techniques for our acquisition, logistics, maintenance, and sustainment professionals; established a dedicated office to lead and coordinate enterprise-level digital transformation; published the Digital Building Code, a Digital Guidebook, and established digital maturity metrics that drive digital practices for new acquisition programs, as well as key legacy programs and modernization efforts; and funded 30+ Small Business Innovation Research (SBIR) projects specifically focused on digital transformation-enabling technologies and products.

Digital transformation is the disruptive enabler to accelerating delivery of warfighter capability. The DAF continues to commit resources and foster partnerships across DoD, industry, academia, and international partners key to ensure relevancy and institute complimentary standards, data, and mission infrastructures. By recognizing the need to evolve our workforce competencies and underlying acquisition systems, the DAF is establishing the foundations of acceleration, innovation, and disruption to deter our adversaries and win tomorrows fight, today.

S&T Portfolio

DAF S&T--One Lab for Two Services

DAF S&T is committed to the missions and superior capabilities of the Air Force and Space Force. Research and technology is cross-cutting in its application across the Services, and technological breakthroughs routinely provide multidisciplinary benefits. The Air Force

Research Lab (AFRL) remains one laboratory supporting both the Air Force and the Space Force.

The DAF S&T budget supports the people and facilities needed to enable the long-term DAF vision through maturation of technology, maintain world class expertise conducting research and development, and transition product and knowledge through a variety of means including partners, programs of record, and the warfighter directly. The AFRL works closely with stakeholders throughout the defense enterprise to ensure our common efforts are not duplicative but rather complimentary. This engagement includes active participation in the OSD Communities of Interest and Joint working groups focused on technology modernization.

DAF S&T is invested to support OSD critical technology areas and modernization priorities and DAF operational imperatives and management initiatives. The following sections provide details on many of these high quality science and engineering efforts.

Artificial Intelligence & Autonomy

Artificial Intelligence (AI) is increasingly critical to national and economic security and Air Force and Space Force missions. AFRL is exploring ways to leverage AI as a game-changing capability implemented across warfighting domains. Recent successes in autonomy and AI include working with the Department of Defense Joint AI Center (JAIC) to deploy and demonstrate the StreamlinedML suite on the JAIC's cloud-neutral platform to streamline algorithm development, evaluation, and deployment costs and timelines by an order of magnitude. In 2021, the Air Force Autonomous Air Combat Operations team flew the first full scale jet controlled by an agent trained with machine learning, paving the way for a series of tests that demonstrated in flight and simulation the value of a tactical autopilot. One example, in partnership with USAF Test Pilot School, the AI-based tactical autopilot flew a live Learjet

alongside a live F-16 lead aircraft against a virtual adversary aircraft (piloted by a human in an advanced ground-based simulator). The AI autopilot executed maneuvers it developed during training simulations which surprised the "adversary" by the unusual yet effective tactics, which simultaneously validated the AI training protocols and demonstrated the value of a tactical autopilot. Following this, AI-powered Command & Control software was showcased at INDOPACOM's third Joint, All-Domain Integrated Fires tabletop exercise, where the AI delivered plans and analysis at machine speed and maintained a digital common operating picture, freeing human planners to focus on meeting strategic objectives in compressed timelines. DAF leads efforts for trusted AI, hosting a Trusted AI Workshop series which brings together national experts from industry and academia to outline the technical challenges associated with certifying self-aware learning systems to safely and reliably operate in society with the appropriate level of autonomy.

Biotechnology

Our biotechnology portfolio takes advantage of advances in the emerging tools and understanding of this rapidly growing area, offering opportunities in new capabilities, including novel materials for military systems, high-performance aerospace fuels, sensing and monitoring of warfighter physiological and cognitive state, operational readiness, and protection from extreme environments. The portfolio is establishing novel non-invasive neuromodulation paradigms such as the individualized neural learning system (iNeuraLS) to accelerate pilot training by 20-40%. Other recent successes employ synthetic biology to overcome supply issues of critical materials by leveraging both a cooperative agreement with the BioMADE national manufacturing institute and the DoD ManTech program to develop advanced biofuels, develop biomolecules to enhance optical properties for laser eye protection, and demonstrate the use of

biocements in military operations. These agile biocement materials enable rapid establishment of infrastructures in expeditionary and contested locations.

Adversaries continue to pursue biotechnology and human performance as a cornerstone of their military strategy; as such, the service laboratories, including AFRL, are closely coordinated through OSD-led Communities of Interest to leverage each other's investments, areas of expertise, and research focus areas. These joint-service activities are critical in shaping the strategic landscape for future biotechnology and bioindustrial manufacturing innovations and infrastructure investments, providing new capabilities for Air Force and Space Force missions.

Cyber, Advanced Communications, and 5G

AFRL's cyber science and technology investment is focused on basic and applied science in electromagnetic and cyber convergence, as well as assurance of complex systems. We have shaped the development and integration of advanced command, control, communications, intelligence, and cyber capabilities to meet warfighter needs for future multi-domain effects delivered through the cyber domain. We bring together industry partners for collaboration though innovative outreach vehicles and events such as Hack-a-Sat, and Tech Warrior: Cyber Ops. With academia, our in-house subject matter experts work closely with visiting professorships, internships, and educational partnership agreements to shape foundational research. Development of the junior scientific workforce's cyber skills is a priority, and AFRL-sponsored training like the Machine Learning Boot Camp ensures a continuous pipeline of talent in this critical area.

In recognition of 5G capacity, data rates, and lower latency, we are partnered with OSD on several initiatives leveraging 5G capabilities, including distributed and mobilized command and control, improved flight-line operations, augmented reality for improved training, and

dynamic spectrum sharing with several Air Force systems. These are joint-service activities that include our Army and Navy partners, as well as industry. We have also established cooperative agreements with international partners to explore the challenges and potential of 5G technology.

Directed Energy

Directed Energy (DE) has extraordinary potential for defending against missile and drone attacks. DAF is defining optimized resilient basing, sustainment, and communications in a contested environment and sees DE weapons as key to defending these bases in a future hybrid base defense architecture. Future DE weapons will save lives as a precise method of stopping ballistic missiles and other major threats. The current budget request includes a significant effort to support advanced technology demonstrations in DE weapons.

Directed Energy weapons harness the power of the electromagnetic spectrum to enable Airmen and Guardians to effectively and affordably strike critical targets across multiple domains at the speed of light. As an example, to meet today's small unmanned aerial system (sUAS) threat, the DAF is developing DE systems that can sequentially defeat multiple UASs singly and in swarms. The DAF DE experimentation campaign continues overseas field evaluations of four counter-sUAS weapons: three high energy laser systems and one high power microwave system.

The three laser systems, together known as High Energy Laser Weapon System (HELWS), have completed weapons system characterization tests, and are deployed in the hands of the warfighters today. The first high powered microwave weapon system for counter-sUAS, Tactical High Power Operational Responder (THOR), has undergone its own risk reduction and system characterization efforts and overseas deployment. These represent the first-ever

operational prototype DE weapon systems, allowing users to provide operational feedback and enable improvements to future systems.

Microelectronics

Maintaining and enhancing a technological advantage in microelectronics over our peer adversaries is essential for national defense. However, we are greatly challenged by the globalization of this technology that threatens assured access. We are postured to address this challenge with DoD, Agency, industry, academic and international partners through initiatives to adopt leading edge commercial advances and development practices; enhance digital engineering infrastructure; extending our cloud-based infrastructure to support rapid innovation across the defense ecosystem; and targeted extension of a robust supply chain for DoD-unique needs and microelectronic solutions.

Development of a DAF microelectronics strategy is underway to characterize semiconductor technology needs, actions to engage national initiatives, standards for assurance of microelectronics solutions, leveraging commercial semiconductor solutions for DAF capability modernization, addressing needs for high-end, DoD-specific operating environments, and growing talent and supporting infrastructure.

Quantum

The DAF is prioritizing the acceleration of quantum technologies and establishing the vision to make the operational use of quantum a reality. AFRL engages with public and private organizations, to enhance research, development, and deployment of quantum information science as well as quantum information science-enabled technologies. The AFRL Quantum Sensing and Timing group collaborated with the Navy to conduct a risk-reduction field test in aboard a Navy-chartered research vessel, demonstrating above-expectation device performance

in an operationally-relevant environment. AFRL is also leveraging commercial investment in quantum computing hardware and focusing on investigating quantum algorithms to solve computationally-hard problems faster than conventional computing systems. AFRL is a hub member of the IBM Q-Network, which enables access to IBM's premiere quantum computing capabilities and allows AFRL to share that access with partners – currently there are 12 partner organizations across government, industry, and academia. AFRL is pursuing agreements for similar access to other commercially-available devices at IonQ, Honeywell, Google, PsiQuantum, and other industry leaders. AFRL, in partnership with the Griffiss Institute, operates the Innovare Advancement Center, an open-innovation facility designed to enable partnerships with non-traditional contractors and international researchers to reach top-talent and technology developments.

Space

The DAF S&T Portfolio is addressing threats posed to the space domain and developing new technologies to maintain superiority over near peer adversaries. In support of Space Domain Awareness, the Starfire Optical Range and the Maui Optical and Supercomputing Site facilitate detection and characterization of dim and maneuverable objects in space. Another focus is the space element of JADC2, advancing space communications and implementing a future hybrid space architecture, shifting from single application satellite constellations to interconnected constellations that disaggregate functionality and provide resiliency in the face of advanced and projected threats.

The commercial space sector has enabled new approaches to technology maturation. An example is AFRL's modular rocket engine program. This affordability-driven initiative with small launch service providers will reduce the time it takes to develop and field a new engine by

80 percent and cut costs by 50 percent. It also enables industry to quickly modify their commercial products to capitalize on emerging DoD requirements for tactically responsive space access.

AFRL's continued leadership in space S&T is exemplified by numerous public-private partnerships and cooperative research and development agreements with over a dozen commercial space companies. These agreements allow the commercial space industry to leverage AFRL infrastructure, technology, and expertise to develop and mature new space capabilities, while benefiting the U.S. government by creating a more robust commercial space ecosystem that is better positioned to address defense needs.

Hypersonics

The Air Force has a long history (over sixty years) in hypersonic science and technology development, and through the Air Force Research Laboratory, we have the longest continuous effort in DoD. Hypersonics is an area where our science and technology activities blend with prototyping, flight testing, manufacturing, and production as examples of successfully S&T transition. The DAF hypersonic portfolio consists of three major thrusts: boost-glide systems; air-breathing cruise missiles; and the enabling and enduring Science and Technology (S&T) hypersonics portfolio.

The Air Force's hypersonics S&T portfolio includes high temperature materials research, advanced rocket and propulsion technologies, and navigation and guidance systems. AFRL has made many enduring contributions to the field of hypersonics including aerodynamics and aerothermodynamics; airbreathing propulsion; solid and liquid rocket propulsion; high temperature materials, weapon effects, structures and manufacturing; guidance and control; and ordnance systems. The High Speed Strike Weapon Technology Maturation (HSSW TM) is an

effort to mature air-launched hypersonic weapons by developing long lead, critical technologies in synchronization with the OSD Hypersonics S&T Roadmap. The Tactical Boost Glide (TBG) is a joint Air Force / DARPA effort seeking to develop and demonstrate technologies to enable air-launched, tactical-range hypersonic boost glide weapons like the Air-launched Rapid Response Weapon (ARRW). The joint Air Force / DARPA Hypersonic Air-breathing Weapon Concept (HAWC) and Air Force / OSD(R&E) HyFly2 designs are key technology enablers for the Hypersonic Attack Cruise Missile (HACM) program.

Climate Considerations

Especially in areas of the S&T portfolio related to manned and unmanned aircraft, we continue to look for cost-effective ways to improve energy and fuel efficiency, reduce greenhouse gas emissions, and fortify our industrial base to develop components and products necessary as aligned with the National Defense Strategy. As previously discussed, the electrification of rotorcraft is being investigated through the AFWERX Agility Prime program. These all-electric or hybrid-electric vehicles are a great example of an important capability that has a variety of potential uses and may also lower emissions. Alternative fuels are being researched, as well as more energy efficient propulsion and electrical power systems. These and other S&T efforts seek to enhance combat performance while minimizing effects on the environment.

Manufacturing Technology

To fully accomplish technology modernization, we must ensure domestic ability to manufacture the components. Whether supporting a prototype of a weapon or a Vanguard, microelectronics component, tech refresh of a current system, or supply chain for an obscure

item, new technological components all must be producible, ultimately at the volume and scale demanded by our warfighters.

AFRL's Advanced Manufacturing office provides a focus on transition of advanced manufacturing technologies (e.g., additive manufacturing, digital thread, automation and robotics, augmented/virtual reality). Activities include standardized guidelines and processes, and engagement with our Air Force and Space Force program offices and materiel commands to place them into practice. Just two months ago, the Air Force instituted a new Technology Assessment Process to facilitate approval of novel advanced manufacturing processes for use in our depots during maintenance, repair, and overhaul of weapon systems.

The DAF is an integral partner in the management of five of the DoD's Manufacturing Innovation Institutes (MII). Involvement with industry experts and the MIIs provides the opportunity to inform and leverage resources, and creates awareness of the DAF's needs with broad networks of companies and universities to include small and non-traditional providers. The expansion of this pool fosters the development of future human capital necessary to sustain our domestic manufacturing enterprise.

Conclusion

The DAF continues to push the boundaries of modern technology to transform warfighting capabilities while improving the science for tomorrow. Above all, we have a workforce that is truly special, driven by a tireless devotion to maturing difficult specialties, making significant discoveries, and applying expertise and creativity to novel problems. Thank you for your strong support of the Air Force and Space Force S&T, the authorities you have provided, and this opportunity to testify.