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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
Presentation to the
Armed Services Committee
of the United States House
Subcommittee on
Cyber, Innovative Technologies, and Information Systems

Statement of:

Ms. Kristen J. Baldwin, Senior Executive Service (SES)
Deputy Assistant Secretary of the Air Force (Science, Technology, & Engineering)

Hearing Date: May 20, 2021

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Chairman Langevin, Ranking Member Stefanik, and distinguished Members of the subcommittee, thank you for the opportunity to provide testimony on the implementation of the Department of the Air Force (DAF) Science and Technology (S&T) Strategy and our continued 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. It is clear that supremacy in the air and space domains—a given for any U.S. military operation since the end of the Cold War—can no longer be presumed without deliberate investments in leap-ahead technology. Consequently, the National Defense Strategy shifts our priority, including that of S&T, to high-end warfighting.

The DAF has fully embraced National Defense Strategy objectives. The Air Force and Space Force must be ready to compete, deter, and win in this rapidly changing and increasingly complex security environment.

Developing and Delivering Transformational Strategic Capabilities

The DAF S&T 2030 Strategy calls for an S&T portfolio consisting of a broad-based, enabling and enduring component, and a new transformational component that develops and delivers game changing solutions for entirely new warfighting capabilities.

In response to this call, we established a Transformational Capabilities Office (TCO) to lead the transformational S&T portfolio to develop multidisciplinary, system-of-systems solutions.

The transformational component is focused on developing leap-ahead capabilities that change DAF operations, fueled by emergent technology but pursued from a system-of-systems level, and executed with focus, urgency, and risk-acceptance. It is differentiated by being driven by future force design, cross-disciplinary in nature, and formulated and managed at the Air Force S&T enterprise level. The S&T 2030 Strategy set an initial target for the transformational component to account for 20 percent of the DAF S&T annual budget. As these disruptive "first in class" systems mature, critical work aligning S&T and advanced component development is necessary and appropriate to bring these innovative technologies into programs of record through robust experimentation and prototyping. These multi-budget activity efforts shorten technology transition timelines, mitigate risk, and reduce acquisition cost.

We have implemented a number of new procedures to identify, prioritize, and govern the transformational component investment. The DAF Warfighter Technologist (WARTECH) process engages with warfighters and technologists to collectively ideate and jointly mature transformational component proposals that address future force requirements. The TCO also manages new competitive processes to ensure a continuous pipeline of ideas. These novel "Seedlings for Disruptive Capabilities" and "Explore" efforts pursue high risk areas of the Air Force and Space Force future designs and drive investments and partnerships that contribute to transformational solutions. The TCO achieved Initial Operational Capability in September 2020, and through the above processes, generated 235 submissions, matured over a dozen Seedling and WARTECH projects, and is executing three multidisciplinary Vanguards.

Vanguards

Within the transformational component portfolio are a select number of premier programs. These Vanguard programs represent a new model for accelerating the pace of

transitioning solutions. From the start, Vanguard program offices are built differently – a collaborative team of personnel from the S&T, acquisition, operator, and test communities. Vanguards also aim for significant technical achievements, not only for component technologies but also integrated systems and systems-of-systems that demonstrate the viability of leap-ahead capabilities to warfighters and the future force. To date, there are three active Vanguard programs moving towards maturity and transition: Skyborg, Navigation Technology Satellite-III (NTS-3), and Golden Horde.

Skyborg is an enabler for airborne combat mass by building an autonomy foundation for a family of layered, unmanned air vehicles. The program is built on a partnership between the Program Executive Officer for Fighters and Advanced Aircraft, the Air Force Research Laboratory (AFRL), and warfighters. Using open system architectures, digital tools, rapid software development, modularity, and expandability, Skyborg represents an innovative way to employ combat capability at a fraction of the cost of traditional systems. Initial hardware and software are currently in the development and integration phase and expected to be flown this summer and fall.

NTS-3 is developing advanced techniques and technologies to detect and mitigate interference to positioning, navigation, and timing capabilities and is increasing satellite navigation (SATNAV) system resiliency for military, civil, and commercial users. From geosynchronous orbit, NTS-3 will conduct one year of experimentation to augment Global Positioning System (GPS), space-qualify multiple integrated advanced technologies, and test concepts of operations for end-to-end resilient satellite navigation. These include electronically-steered phased array antennas, flexible and secure signals, software-defined GPS receivers, ground control segment automation, and use of commercial ground antennas. 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, we have entered the manufacturing and test phase and are 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. Shipping of the satellite bus from our partners' manufacturing facility to the test and integration facility is anticipated later this year and integration of the advanced payload to the bus in subsequent months. Launch is slated for Fiscal Year 2023.

Golden Horde is demonstrating the mission effectiveness of networked collaborative weapon capabilities for our warfighters. Networked collaborative weapons share data, interact, and develop and execute coordinated actions or behaviors across an entire group of weapons. The program successfully completed a flight test in February 2021, which included four Small Diameter Bomb weapons in collaborative flight and synchronized time-on-target. We are now beginning a new phase to plan and build a digital environment, with a government-owned reference architecture where various collaborative autonomous networked technologies can be rapidly tested and improved.

Rapid transition of emerging technologies into warfighters' hands is imperative to ensuring the DAF stays ahead of potential adversaries. Robust experimentation and prototyping enables risk reduction of disruptive technologies and employment of existing systems in new ways to understand the operational competitive advantages and quickly integrate them into our force structure. These investments provide critical insights into operational utility and technical feasibility of a new warfighting concept, and inform appropriate acquisition pathways. The DAF Strategic Development Planning and Experimentation (SDPE) Office, located within AFRL,

executes these prototyping and experimentation activities, focusing on the most significant operational needs identified by senior DAF leadership, and teams from Space Force Futures & Integration and Air Force Futures.

A few examples will help illustrate the impact of our current prototyping and experimentation work. The Global Lightning effort is empirically testing the operational utility and competitive advantages of using commercial space-based internet to deliver robust gigabit-per-second class data rates and low latency communications to support tactical missions, in conjunction with traditional military communications. Our strategy has been to select a small number of platforms (i.e., AC-130, KC-135, and F-35) and rapidly deployable ground terminals, conduct field testing, and then transition to operational deployments. This successful effort 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 cooperation across the Services and Commands, 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.

Additional successes include fielding of directed energy weapons as part of an operational theater deployment to assess utility in real-world applications; successful two-ship flight experiment in support of the Skyborg Vanguard at China Lake, California, in November 2020 that validated autonomy behaviors and the modeling and simulation environment; and demonstration of the Rapid Dragon palletized munitions prototype in support of an initial capability for cargo aircraft to deploy existing long-range munitions. Joint Air-To-Surface Standoff Missile – Extended Range live-fire tests from a C-130 are scheduled for December 2021 and from a C-17 in March 2022.

In addition to accelerating development of individual system capabilities we also need to bring families of systems (or systems-of-systems) together into a unified DAF technical architecture. Two primary lines of effort will produce this holistic architecture. First, we will create and mature architectures that are oriented both horizontally across mission areas and vertically within programs and platforms themselves. Second, we will experiment with and test these systems-of-systems through Architecture Demonstration and Evaluation events. Architecture Demonstration and Evaluation events not only focus on networking solutions in support of Joint All Domain Command and Control (JADC2), but also provide the ability to identify mission-critical gaps and potential solutions that might not have been found through program specific developmental and operational testing. By building a common department-wide technical architecture using open systems and open standards we will be able to adapt and upgrade components, systems, platforms, and systems-of-systems quickly in response to threats or opportunities as technological advances are made.

DAF S&T--One Lab for Two Services

The DAF is committed to the missions and superior capabilities of the Air Force and Space Force. As concepts and capabilities emerge for the space warfighting domain, S&T is agnostic. Technological breakthroughs routinely provide multidisciplinary benefits. Autonomy, quantum, and microelectronics technological advances cut across domains and will benefit both the Air Force and the Space Force. Rapid densification carbon-carbon was initially explored for intercontinental ballistic missiles, but is now transitioning to space launch vehicles and solid boosters.

The AFRL will remain one laboratory supporting both the Air Force and the Space Force. To facilitate integration and coordination, we established an additional position within AFRL,

the Deputy Technology Executive Officer (TEO) for Space S&T. The Deputy TEO is charged with integrating the development and execution of Space S&T efforts across all domains and technology areas. The Deputy TEO engages with the space enterprise to align AFRL's technical portfolio to spacepower core competencies. Through the Deputy TEO, research and development advancements across government, commercial, and academic sectors are leveraged to optimize space S&T.

Deepening and Expanding the S&T Enterprise

In Fiscal Year 2021, the DAF expanded and strengthened its partnerships, drawing technology out of universities, industry, and other government organizations. We leveraged resources and talent in basic research, as well as made great strides in bolstering our relationship with non-traditional industry.

Partnerships

Leading in innovative partnerships, AFWERX continues to transform the way we work with commercial companies. AFWERX experienced several modifications last year, including a move to Air Force Materiel Command, where AFRL provides organize, train, and equip functions, while the Service Acquisition Executive maintains overall strategic oversight. In December 2020, the approval of SpaceWERX was announced followed by the merger of AFWERX with the Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Center of Excellence in January of this year.

Starting in 2018, the DAF explored ways to lower barriers for commercial tech companies to enter into the defense market. By partnering the AFVentures process with our SBIR/STTR team in 2020, we awarded over 2,000 contracts worth $700 million to 1,400 small businesses, with over 75 percent of the recipients being new partners with the DAF.

In addition, the DAF explored ways to further enhance military missions by accelerating emerging commercial markets. To that end, Agility Prime was launched under AFWERX to operationalize electric vertical takeoff and landing vehicles (i.e., "flying cars") from the commercial market. Agility Prime has been leveraging the DAF's unique technology, testing, and safety resources to mitigate current commercial market and regulatory risks, as well as attract investors, build confidence, and expedite commercialization. We appreciate the support of Congress on this effort.

Through the use of Technology Interchange Meetings (TIM) with U.S. companies, the DAF leverages approximately $5 billion of investments in its Independent Research and Development (IR&D) program. On average, AFRL annually conducts five major TIMs, connecting with approximately 50 industry leaders per year, to couple areas of focus between the DAF and IR&D initiatives and to further leverage industry investments toward Air Force and Space Force mission needs. In Fiscal Year 2020, COVID significantly impacted classified IR&D engagements with a number of our industry partners.

In April, the DAF requirements and technology leaders hosted the first bi-annual Strategy Interchange Meeting (SIM). This multi-day event was open to large, medium, and small businesses, academia, and national laboratories and provided an opportunity for exchange with DAF leaders and discussion of strategic direction, priorities, future capability needs, and technology challenges. Plenary and one-on-one sessions were held with participants to discuss emerging concepts and innovative solutions.

International partnerships remain a strategic imperative and the DAF continues to work with partner nations to collaboratively develop and adopt game-changing technologies to meet near peer adversary innovation and investment. In Fiscal Year 2020, DAF subject matter

experts were involved in over 220 activities and technical interchange opportunities, attending virtual conferences, participating in scientist exchange programs, and attending various events for the North Atlantic Treaty Organization (NATO) and the Five Eyes (FVEY). Currently, over $500 million of the DAF S&T is associated with international partner agreements and grants across multiple nations. These partnerships extend and leverage international expertise in all of the DoD modernization priorities. For example, the DAF in partnership with OUSD(R&E) Mission Prototypes (MP) is collaborating with the Royal Australian Air Force (RAAF) on the Southern Cross Integrated Flight Research Experiment (SCIFiRE). SCIFiRE leverages nearly two decades of the DAF S&T investments in the field of hypersonics and will advance air-breathing hypersonic technologies into affordable, full-size prototypes providing flexible and long-range capability, culminating in flight demonstrations in operationally relevant conditions. The deliberate partnership with Australia could lead to future co-development and/or co-production of various systems and subsystems to increase industrial base capacity.

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, and implement best practices and standards. We are an active participant in an OSD-led research protection group comprising all Services and other Defense Agencies. We are piloting the application of open source analysis to examine risks associated with research grants, including conflict of interest and conflict of commitment. These efforts are informing strategies and processes that will implement government-wide guidelines for critical technology protection.

Human Capital

The DAF S&T Strategy recognizes technological superiority depends on the talent and innovative spirit of our workforce. Competition for technical talent will continue to intensify and the DAF is committed to building a highly-qualified and diverse team. AFRL is implementing a new human capital approach that institutionalizes strategic foresight; incorporates scanning, piloting, and application of best workplace practices; seamlessly integrates the human capital lifecycle; and fortifies the alignment of a Human Capital Strategy to the enterprise learning, organizational agility, and capability delivery needs of the organization. Importantly, this approach also incorporates a data-driven decision making framework focused on workforce enablement, productivity, optimization, organizational agility, collaboration, and satisfaction. This approach was reviewed and endorsed by two independent panels of academia, industry, and government science and technology experts via the Fall 2020 Scientific Advisory Board and again at the Spring 2021 Air Force Studies Board.

The competition for the right 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 such as Flexitour, Maxiflex, and Compressed across the enterprise. In our pursuit of removing roadblocks and continuously scanning for best practices, AFRL most recently adopted five new S&T Reinvention Laboratory (STRL) flexibilities from other DoD Laboratories. Additionally, AFRL spearheaded the push for an STRL omnibus federal register to obtain seven novel incentive authorities to help us obtain and retain world class diverse talent.

The AFRL's Office of Scientific Research (AFOSR) provides more than 1,500 grants valued at approximately $450 million to over 200 U.S. universities annually. Our outreach to Historically Black Colleges and Universities/Minority Serving Institutions (HBCU/MSI) provides $4.5 million in grants annually. While AFOSR is an excellent example, other AFRL mission organizations contribute significantly above these numbers to meet their specific mission needs, including over $20 million in additional grants to HBCU/MSIs.

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 125,000 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.

Digital Transformation

The DAF recognizes near-peer nations are accelerating the evolution of their warfighting capabilities at a rapid pace through significant investment in research and development and digital transformational initiatives. Meanwhile, our ability to field capabilities continues to slow down due to our ever-increasing weapon system complexity. Not only must the U.S. develop new, disruptive capabilities, we must address how we develop and acquire technologies and get them to the field at the speed of relevance. Acceleration will depend on three key imperatives:

1. We must enable capabilities to operate in shared cross-organizational, virtual environments that all the services, industry, and our academic partners can use.
2. We must apply smart coding and containerization to bring automation and secure functionality to end users and warfighters.

3. We must follow "eCreate" practices in the development of our systems to identify issues earlier, iterate faster, and optimize solutions in a safe, and less expensive, virtual environment.

This transformation is built upon a "digital trinity" of digital engineering, agile software development, and open systems architecture. Fully digital approaches will be used to assist in managing our engineering, research, mission, and business system development. Agile software development will provide assured continuous improvement in security and capability delivery. Open systems architecture will maximize our mission flexibility, drive acquisition competition, enable access to innovative technologies, and lead the way to relevant modernization. Also at the core of our digital transformation efforts is developing and maturing our workforce to adopt an advanced level of digital proficiency. Enabled by this Digital Trinity, and a digitally capable workforce, this transformation is the only way to avoid delivering today's technology for tomorrow's fight.

S&T Portfolio

The DAF S&T budget supports the people and facilities needed to conduct three major missions: enable the long-term DAF vision through maturation of technology, develop subject matter expertise via conducting research and development in those areas, and transition product and knowledge through a variety of means including industry, programs of record, and the warfighter directly. Using technology horizon scanning capabilities and demand signals from Major, Field, and Combatant Commands, we execute a balanced technical portfolio maturing technical solutions for current and future challenges. To facilitate transition of knowledge and products, the AFRL works closely with stakeholders throughout the Department enterprise,

industry, and other Services. This engagement includes active participation in the OSD Communities of Interest focused on the modernization of the military.

Despite COVID-19, we had an exceptional year responding to both emergent and enduring technology needs for the DAF while pushing the leading edge of S&T. Aligned with the DoD Modernization Priorities, below are more details on the many high quality science and engineering efforts across the DAF.

Artificial Intelligence & Autonomy

Artificial Intelligence (AI) is increasingly critical to national security and achieving the current and future Air Force and Space Force missions. Recent successes in autonomy and AI include the operational deployment of AI models to analysts in the Air Force Distributed Common Ground System (DCGS), resulting in a 90 percent reduction in time required to produced labelled data; demonstrating a prototype that optimizes the control of satellite communication beams; conducting data processing on the edge and enabling the dissemination of tactical information for real-time decision making with a reduced bandwidth by a factor of 100 to 1,000X; and delivering a software upgrade that increased analyst productivity by making an existing manual, time-consuming process autonomous. This new automation reduced the work per file by 99.97 percent and greatly increased U.S. Southern Command mission effectiveness to track drug smugglers. In December 2020, the Air Force demonstrated the ability for AI to assist our intelligence, surveillance, and reconnaissance mission by having an AI system fly as a co-pilot for the U-2 Dragon Lady. While the AI only controlled the sensors and tactical navigation systems, the event showed that trusted AI systems will play a critical role in future Air Force operations.

Also of note is our leadership in Trusted AI, where we are hosting a Trusted AI Workshop series to bring 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 tools and understanding of this growing area, and seeks to transcend current constraints to build new materials for military systems, enable new methods for sensing and monitoring, augment performance, protect the warfighter from extreme environments, and ensure readiness. For example, physiological sensors and predictive analytics have enhanced operator and environmental state assessment, leading to increased readiness for multiple operational communities, including special operators, aircrew, and maintainers. Other recent successes employ synthetic biology to overcome supply issues of critical materials systems, develop biomolecules with enhanced optical properties for laser eye protection, and use biocementation for dust mitigation/prevention of brown outs. Peer competitors 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 interests to leverage each other's investments, areas of expertise, and focus areas. We are also collaborating with a number of international partners to advance materials and human performance research.

Cyber, Advanced Communications, and 5G

Cyber operations are of increasing importance to all Air, Space, and joint missions, and central to Air Force and Space Force objectives for Joint All Domain Operations. The 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 would be happy to share more information in a classified setting.

In recognition of 5G's significantly greater capacity, enhanced data rates, and lower latency compared to today's 4G long-term evolution (LTE) cellular networks, we are partnered with the Office of the Under Secretary of Defense for Research and Engineering 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 our industrial base contractors. We also work with our international partners through cooperative agreements to explore the challenges and potential of 5G technology.

We bring together industry partners for collaboration in these areas though innovative outreach vehicles through events such as Hack-a-Sat and Tech Warrior: Cyber Ops. In-house talent also works closely with academia though visiting professorships, internships, and educational partnership agreements to shape foundational research. Development of the junior scientific workforce's cyber skills is also a priority, and AFRL-sponsored training like the Machine Learning Boot Camp ensures a continuous pipeline of talent in this critical area.

Directed Energy

Directed Energy (DE) 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. To meet today's small unmanned aerial system (sUAS) threat, AFRL is developing DE systems that can sequentially defeat multiple UASs singly and in swarms. As part of the DAF Directed Energy Experimentation Campaign, we continue progress on the first-ever extensive overseas field evaluation consisting 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, are deployed in the hands of the warfighter, and represent the first-ever Air Force operational DE systems. The first high powered microwave system for counter-sUAS, Tactical High Power Operational Responder (THOR), has undergone its own risk reduction and system characterization efforts and preparation for overseas deployment, allowing users to provide operational feedback and enable improvement to future systems.

Microelectronics

Maintaining and enhancing a technological advantage in microelectronics over our peer adversaries is essential for our national defense but greatly challenged by the globalization of this technology area. Thanks to the congressional authority that enabled us to hire top talent with enhanced pay authorities, we are postured to address this challenge through rapid adoption of leading commercial advances and development practices, enhancement of a digital engineering infrastructure, and targeted extension of a robust supply chain for DoD-unique needs and microelectronic solutions.

We are adopting microelectronics development processes that mirror the best of U.S. commercial industry leaders and extend our cloud-based infrastructure to support rapid innovation among academic, small business, and industrial base partners. We piloted digital

engineering evaluation techniques and digital thread technologies to enable the use of state-of-the-art microelectronic devices in our systems by providing the needed trust and assurance.

We continue to explore emerging microelectronic advances leveraging commercial semiconductor processes for high-end, DoD-specific operating environments, and capitalize on our organic government expertise and facilities to propel these forward.

Quantum

The DAF is prioritizing the acceleration of quantum technologies by committing resources in response to demand signals and establishing the vision to make the operational use of quantum a reality. As such, the Acting Secretary for the Air Force in accordance with Section 220 of the National Defense Authorizations Act for Fiscal Year 2020 designated AFRL as a Quantum Information Science Research Center. The center engages with public and private organizations, including academia, to enhance and accelerate the research, development, and deployment of quantum information science as well as quantum information science-enabled technologies. The DAF continues to align with OSD's modernization strategy and invest in the four primary application areas of quantum information science (QIS): timing, sensing, communications/networking, and computing. In the area of quantum timing the AFRL is developing deployable air/space atomic clocks with picosecond per day drift for more precise synchronization of platforms, weapons, and sensors in contested environments. The 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.

We are taking a strategic stance on long-term foundational advancements in order to drive and establish the future industrial base that will enable the U.S. to dominate the battlefield

of the future. Together with industry, academia, and government, we are building a quantum ecosystem by developing the supply chain through the recently-completed Virtual Quantum Collider and the One-Million Dollar International Quantum U Tech Accelerator to accelerate the rate of advancements in the field. Through these efforts, we awarded 35 contracts of $150,000 each to 23 small businesses and universities for a total exceeding $5 million to accelerate our learning and implementation of these technologies.

Space

The DAF S&T Portfolio is addressing threats posed to the space domain and developing new technologies to maintain superiority over our 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 (CRADAs) with over a

dozen commercial space companies interested in access to DAF facilities and expertise. The AFRL and Space and Missile Systems Center will conduct a rapid launch ground operation demonstration with industry partners this year, fostering deeper understanding across the enterprise of the challenges with rapid launch operations.

Hypersonics

Our near-peer adversaries will contest access to all warfighting domains – air, land, sea, space, and cyberspace. Therefore, we must field a combination of weapon systems and effects with greater speed, reach, and survivability to deter, fight, and win the wars of the future. Hypersonic systems, which fly at speeds of Mach 5 and greater, offer the potential to significantly reduce our response times and engage time-sensitive and high value targets in highly contested environments with greater effectiveness. The DAF continues to partner with DARPA to develop, demonstrate, and transition critical technologies for air-launched hypersonic cruise missiles and boost-glide weapons by FY22. Together, we are transitioning glide vehicle, solid rocket motor, ordnance, and manufacturing technologies from the Tactical Boost Glide (TBG) and High Speed Strike Weapon Technology Maturation (HSSW Tech Mat) programs to the Air-launched Rapid Response Weapon (ARRW) rapid prototype program.

Vitally important as well, the DAF works closely with the DoD, Department of Energy, National Aeronautics and Space Administration, industry, universities, and allied partners to prioritize, execute, and coordinate science and technology development for hypersonic weapons, air platforms, and tactically responsive space access.

Manufacturing Technology

Our 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 Enterprise to place them into practice.

To fully accomplish technology modernization, we must ensure we have the ability to manufacture the components. Whether supporting a prototype of a weapon or a Vanguard, microelectronics, or an upgrade to a current system, new technological components all must be producible, ultimately at the volume and speed needed by our warfighters. The DAF is an integral partner in the management of six 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. These networks of small and non-traditional providers also foster development of future human capital necessary to sustain our domestic manufacturing enterprise.

Conclusion

The DAF continues to push the boundaries of modern technology while improving the science for tomorrow. Above all, we have a workforce that is truly special, driven by a tireless devotion to learning 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.