IMPLEMENTATION OF THE 2030 SCIENCE AND TECHNOLOGY STRATEGY ACROSS THE DEPARTMENT OF THE AIR FORCE

United States Air Force
Presentation to the
Armed Services Committee
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Subcommittee on
Emerging Threats and Capabilities

Statement of:

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Chairman Kelly, Ranking Member Ernst, and distinguished Members of the subcommittee, thank you for this opportunity. It is an honor to provide testimony on the implementation of the 2030 Science and Technology Strategy across the Department of the Air Force (DAF).

Accelerating Development of Innovative Technologies for Warfighters

The DAF has a comprehensive technology portfolio, deep technical scientist and engineer bench, and world class facilities that accelerate development of innovative technologies for Airmen and Guardians.

The National Defense Strategy forecasts a highly contested future fight with complex threats. Peer competitors are driving to overtake the United States as the science and technology (S&T) superpower. The global commercial sector is outpacing our investment in S&T and exploding with innovative technologies. Nonetheless, we remain clear-eyed about the challenges ahead.

With the complexity of this evolving landscape, we accelerate change in line with the Air Force Chief of Staff's charge to us. We accept appropriate levels of risk in innovation and experimentation, as the Chief of Space Operations urges. Above all, we recognize technological superiority is necessary to address these challenges. The Air Force Research Laboratory (AFRL) remains united as One Lab supporting both the United States Air Force (USAF) and United States Space Force (USSF), as we implement the three pillars of the Department's 2030 Science and Technology Strategy:

- Develop and Deliver Transformational Strategic Capabilities,
- Reform the Way Science and Technology Is Led and Managed, and
- Deepen and Expand the Scientific and Technical Enterprise.

Before delving into each of these topics, it's imperative to first review our S&T community's substantial efforts to support the Nation's response to COVID-19.

COVID-19 Response

While the DAF continues to protect the health of the force and maintain operational readiness, a small team of military and civilian personnel at AFRL was tasked with increasing domestic production of personal protective equipment and mitigating economic damage to the defense industrial base through the COVID-19 crisis.

The Defense Production Act (DPA) Title III Executive Agent Program Office (EAPO) successfully awarded over $858 million under the Coronavirus Aid, Relief, and Economic Security Act (CARES Act), in coordination with the Office of the Secretary of Defense Office for Industrial Policy and the DAF Acquisition COVID-19 Task Force. Of the funds awarded, approximately $181 million and $677 million were awarded to the medical industrial base and the defense industrial base, respectively. Within just five days of White House approval, the team executed three contract awards to industry. This would not have been possible without the project engineers, lawyers, and policy, contracting, and financial experts on AFRL's DPA Title III EAPO team and their herculean efforts to support our national defense industrial base capabilities.

AFRL is also home to the DAF's only clinical reference laboratory, which was authorized to test COVID-19 samples. Since that time, the 711th Human Performance Wing Epidemiology Lab has tested more samples than any other Department of Defense (DoD) laboratory – 13% of the total samples across the DoD, including those from the USS Theodore Roosevelt.

In addition, numerous researchers within our S&T community responded to the call by investigating the use of electromagnetic waves to reduce the transmission of COVID-19, employing computational modeling to forecast COVID-19 migration, designing a transport system for air-evacuated COVID patients, vetting and providing feedback to numerous ideas from industry, and evaluating the compatibility of decontamination technologies for the USAF fleet.

Notwithstanding the above accomplishments, our S&T community is driven by an enduring commitment to the Warfighter and solving the complex challenges they face in the air and space domains.

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, AFRL established the Transformational Capabilities Office (TCO) to lead the transformational S&T portfolio and work across technology directorates to develop multidisciplinary, system-of-systems solutions. A major thrust of this office is to lead a new process called WARTECH, which invites warfighters and technologists to co-ideate and jointly mature proposals that address future force requirements. The TCO also developed new competitive processes to ensure a continuous pipeline of ideas coming from the laboratory and throughout the DAF. 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, including Vanguards. 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 sponsored three multidisciplinary Vanguards to date.

Vanguards

Vanguards represent a new model for accelerating the pace of transitioning solutions. From the start, Vanguard program offices are built differently – a collaborative team between 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 a Vanguard to enable 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, 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 position, 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, increased 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 of 2021, which included four Small Diameter Bomb weapons in collaborative flight and synchronized time-on-target. We are now at the beginning of a 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.

Reforming the Way S&T is Led & Managed as One Lab, For Two Services

The DAF has long recognized the importance of Space Superiority to our National Defense, and with the recent standup of the United States Space Force (USSF), has taken steps to demonstrate its commitment to both the Air Force and the Space Force as independent Services.

In September of 2020, AFRL stood up an Interim 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 thrust areas. The Deputy TEO engages across the space enterprise to align our processes and technical portfolio to USSF Core Competencies. In identifying S&T solutions that apply to the Space Force, the DAF will not create barriers. Rather, we will continue to encourage problem-solving across multiple domains, multiple disciplines and actively develop cross-cutting solutions.

In fact, as One AFRL, we are taking a multi-domain approach for swift development of technologies in support of both Services. For example, rapid densification carbon-carbon was initially explored for non-space programs such as intercontinental ballistic missiles, but is now transitioning to space applications which include launch vehicles and solid boosters.

We are working to address threats posed to the space domain and develop new technologies to maintain superiority over our near peer adversaries. In the area of Space Domain Awareness, our world-class facilities at the Starfire Optical Range and the Maui Optical and Supercomputing Site facilitate detection of dim and maneuverable objects in space to ensure there are no surprises. Another area of emphasis is the shift to a hybrid space architecture, where we move from single application satellite constellations to interconnected constellations that use multiple different types of satellites to provide a capability. The hybrid architecture allows new technologies and flexibility across the space domain to keep the United States ahead of the competition.

The commercial space sector has energized our transition record. A good example is AFRL's modular rocket engine components, which are transitioning to small launch service providers. This affordable, modular approach, in conjunction with our advanced modeling tools,

should accelerate the time it takes to develop and field a new engine by 80% and reduce development costs by 50%. This approach enables industry to quickly modify their commercial products to capitalize on emerging DoD requirements for tactically responsive space access, such as scaling small launch vehicles to medium class vehicles.

Our continued leadership in space access S&T is exemplified by a number of Public-Private Partnerships and Cooperative Research and Development Agreements (CRADAs) with over a dozen commercial space companies looking to use our facilities and leverage our expertise. In partnership with Space & Missile Systems Center and industry partners, we are conducting a rapid launch ground operation demonstration this year. This will be executed by Space Force Guardians and significantly increase our understanding of the challenges with rapid launch operations. We expect this first demo to be followed by an actual launch later this year. In all, AFRL has approximately 860 active CRADAs in support of both the USSF and USAF to mature technology using industry investments and re-leverage technology through technology transfer opportunities.

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 stood up a new strategic partnering office and used new approaches to grow and strengthen our commercial, government, and academic partnerships, and 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 Innovative Research/Small Business Technology Transfer (SBIR/STTR) Center of Excellence in January of this year. Together, AFWERX enables the DAF to transition capabilities by teaming commercial and defense industry developers with Airmen and Guardian talent.

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% 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, including the additional $25 million appropriated for Fiscal Year 2021.

Through the use of Technology Interchange Meetings (TIMs) with U.S. companies, the DAF leverages approximately $5 billion of investments in their 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 industry research and development (R&D) initiatives and to further leverage industry investments toward USAF and USSF mission needs. In Fiscal Year 2020, COVID significantly impacted classified IR&D engagements with a number of our industry partners.

On the international front, AFRL has continued to work with our partner countries to collaboratively develop and adopt game-changing technologies to meet near peer adversary innovation and investment. In Fiscal Year 2020, AFRL Senior Leaders met with their allied counterparts for 11 engagements to discuss country portfolios and outline the way forward for continued S&T cooperation. Our 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 (FVEYs). Additionally, AFRL conducted 36 virtual workshops with current and emerging partners, leveraging partner innovation, expertise, and resources. Today, we maintain and continue to develop long-lasting partnerships with 23 international allies – establishing 14 new international agreements with 10 countries in 2020.

Over the last year, the Lab Commanders Sync working groups (WGs), consisting of subject matter experts from each Armed Service laboratory, met regularly to share best practices, identify roadblocks, and achieve Joint goals in their specific fields. The Data Analytics WG developed a Joint tool (Dory/BRIDGES) to provide an interactive exploration of R&D programmatic data from each Service in one platform; the International Partnerships WG developed courses of action (COAs) to shorten the international agreement timeline, which will be briefed to the Commanders later this month; the S&T Metrics WG is exploring how AFRL Transition Metric can be used as a first step toward establishing a common, Joint S&T metrics lexicon; and the Talent Management WG determined no formal personnel exchange program

exists between Armed Service laboratories and is developing COAs to establish an official exchange mechanism.

AFRL has numerous touchpoints through a partnership with the Defense Advanced Research Projects Agency (DARPA) in areas spanning the DoD Modernization Priorities. Over 150 jointly funded initiatives involve AFRL Contracting Officer Technical Representatives supporting mission specific interest areas for our Human Performance, Aerospace Systems, Materials and Manufacturing, Munitions, Sensors, Directed Energy, Information, and Space Vehicles directorates.

AFRL's Office of Scientific Research (AFOSR) provides some 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/MSIs) 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.

In order to facilitate connections between potential partners and the Air Force and Space Force S&T enterprise, an innovative business process was set up last year. The DAF created a more accessible virtual S&T front door through Air Force Tech Connect and Space Force Tech Connect. Tech Connect enables academia, industry, and others to submit ideas that are matched to our database of technical experts across the DAF. This innovative business process enables collaboration with new and existing partners, as well as with each other within the S&T and Innovation enterprise. Since January 2021, over fifty successful connections have been made, resulting in further evaluations to meet the Warfighter needs. By expanding our presence and creating more visible and convenient virtual front doors, we are cultivating a world-wide

ecosystem of research from basic to applied that drives the pace of technology and competition in the agile pursuit of innovative solutions for Warfighters and stakeholders alike.

AFRL created the Air Force Regional Hub concept. This concept aims to establish regional hubs of academia, industry, and government to promote side-by-side collaboration between the DAF and external ecosystem scientists and engineers in areas of interest for the USAF/USSF and the commercial marketplace. Each Hub leverages regional academic and innovation infrastructure and institutions; the acumen of the region's industrial, entrepreneurial and venture-capital community; and AFRL's world-class science and engineering personnel, unique facilities, small business development vehicles, and strategic understanding of future DAF requirements to deepen and expand the S&T enterprise and to strengthen talent through workforce development and recruiting opportunities. Furthermore, to support the growing needs of the USSF, AFRL is establishing the Space University Research Initiative (SURI) supporting both basic and applied research in Space-related science and engineering at U.S. universities, with the potential transition to critical applications of DoD interest. The SURI is comprised of teams from multiple universities/departments to assemble the expertise necessary to address Space-related topics (e.g., Space Logistics and Mobility, Space Domain Awareness).

Together, this robust network of partnerships joins a wealth of knowledge and domain specific expertise to ensure we maintain awareness of the cutting edge research to apply to Air Force and Space Force needs.

Human Capital

Of all the things we do to deepen and expand our S&T enterprise, growing and maintaining high quality scientists and engineers is at the top of the list. Without doubt, the DAF has an exceptionally talented workforce who provide our competitive advantage. To continue to

build the best team, the AFRL piloted a series of workforce studies to better understand possible changes in the future and the implications for our S&T workforce. We uncovered an enduring need to shift away from a transactional personnel approach to a systems and enterprise approach that supports the multiple dimensions of our human capital now and into the future.

As a result, AFRL developed 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 enterprise learning, organizational agility, and capability delivery. Importantly, this approach also integrates data-driven decision making and addresses the multiple, inter-related dimensions of human capital to support the individual, the team, and the organization. The framework for this approach was reviewed and endorsed by an independent panel of academia, industry, and government science and technology experts.

AFRL has hired a new intern pipeline coordinator and K-12 Science, Technology, Engineering, and Mathematics (STEM) Director. The intern pipeline coordinator works with partners from academia, government, industry, and not-for-profit organizations to recruit students and mentors from throughout the state, including populations underserved and under-represented in STEM. We are mentoring, as well as recruiting, at multiple virtual HBCU/MSI hiring events and creating regional locations for the summer apprenticeships to take place at college campuses, university satellite locations, or other STEM partner facilities. We will identify STEM and culture/career mentors to work with the apprentice in-person and remotely. Our goal is to create a bridge between current K-12 STEM outreach efforts and undergraduate/graduate internship programs that will promote increased diversity and inclusion in the future DoD talent pool.

Using a combination of internal surveys, interviews, and other education industry metrics, our K-12 STEM Director created a baseline of the program's current status. The findings of this assessment concluded AFRL STEM Outreach had several strong educational programs but operated with little coordination or collaboration across the enterprise. To create a more cohesive STEM ecosystem-focused program, the K-12 STEM Team will engage in a three-year strategic plan initiative focusing on a holistic education framework for creating both local and national STEM experiences. Project ROADMAP (Reaching Our Audiences by Developing Mission Aligned Programs) will focus our work on community/audience needs, ensuring programs meet the DAF Mission and create STEM networks for larger impact.

Recently, AFRL partnered with the National Science Foundation (NSF) to shape the future of NSF solicitations to couple similar interest areas of S&T. The NSF Intern Program is an expansion of this partnership whereby AFRL contributes to grants for graduate students supported by NSF grants to conduct research internships of up to six months at non-academic research locations. This partnership allows approximately 20 graduate students per year to engage in internships at AFRL research sites to further expand S&T research that closely aligns with both the NSF and the DAF areas of interest. The Edison Grant program promotes a cultural shift towards Airmen and Guardians using flexible, innovative technical skills needed to rapidly judge and adapt to adversaries in a technocentric battlespace, and assess the maturity of technologies and systems with the potential value to the future Air Force and Space Force. The Edison grants will support technical workforce development by allowing military members to learn by doing and testing.

Our in-house talent works closely with academic institutions across the nation not only to leverage their research advancements and shape our own basic and applied research programs,

but also to attract a larger, highly talented, diverse pool of applicants and develop a U.S.-citizen workforce skilled in technology areas to meet the future needs of the Air Force and Space Force.

Personnel Authorities

Congress has provided the DAF with numerous authorities, enabling us to create a pipeline of Air Force and Space Force scientists and engineers, and granted us the flexibility to recruit, hire, and retain top talent. 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, such as the enhanced pay authority (EPA) positions. We greatly appreciate the support from Congress which has allowed us to hire top-notch talent in cutting-edge areas, including Communications and Networking, Modeling Simulation and Analysis, Microelectronics, Data Analytics, and Autonomy.

In order to stay competitive in attracting, hiring, and retaining a diverse world class workforce, AFRL 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. We are dedicated to searching for, creating, and implementing new and enhanced business processes to enable us to build the best S&T workforce, as One Lab in support of the USAF and USSF.

Digital Transformation

The DAF is actively pivoting to digital engineering solutions to increase the use of authoritative data and models to rapidly develop, analyze, and deliver solutions to warfighting forces. AFRL embraced this challenge and established a digital transformation team to deliver S&T capabilities at an ever-increasing speed and efficiency. We piloted digital engineering

evaluation techniques and digital thread technologies to facilitate technology transition. We are also capitalizing on enterprise-wide efforts to optimize business and technical processes, enhance accessibility to authoritative sources of truth, enable cross-enterprise collaboration, improve infrastructure reliability and cybersecurity, and foster workforce development to mature our digital proficiency.

S&T Portfolio

Our S&T budget supports the people and facilities needed to conduct three major missions: create the long-term technical vision for military unique S&T needs, 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, we invest our dollars to avoid duplication and build complementary efforts with our partners and industry. Every day, this talented workforce handles numerous routine and urgent calls from the field, from the program offices, and from the Major, Field, and Combatant Commands.

Importantly, we seek opportunities to achieve future operational dominance through investment in relevant scientific areas, such as artificial intelligence, autonomy, biotechnology, cyber, quantum, microelectronics, and hypersonics. 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 our USAF and USSF 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% reduction in time required to produced labelled data; demonstrating a prototype which 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 1000X; 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% and greatly increased U.S. Southern Command mission effectiveness to track drug smugglers. 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. Adversaries continue to pursue biotechnology and human performance as a cornerstone of their

military strategy; as such, the Service laboratories, including AFRL, have a tightly integrated technology portfolio leveraging each other's investments, areas of expertise, and focus areas.

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. 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 USAF 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's 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. To advance the transition of DE Weapon systems, AFRL is working with industry on additional prototypes to be delivered by the end of 2021 for further warfighter evaluation and partnering with the Department of the Army and Joint Counter-sUAS Office on additional transition opportunities. Finally, we recognize the importance of maintaining a strong shield against adversary DE capabilities and AFRL leads the way in addressing that growing threat through its Counter-DE Weapon program of research and technology development.

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, AFRL 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 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. 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.

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. AFRL continues to partner with DARPA and the Air Force Life Cycle Management Center (AFLCMC) 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 AFLCMC Air-launched Rapid Response Weapon (ARRW) rapid prototype program.

AFRL also 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.

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.