RESEARCH
AND ENGINEERING

UNDER SECRETARY OF DEFENSE
3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3030

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SUBJECT: USD(R&E) Technology Vision for an Era of Competition

The Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E) will spearhead a National Defense Science and Technology strategy for the Department of Defense (DoD), informed by the 2022 National Defense Strategy (NDS) and structured around three strategic pillars: mission focus, foundation building, and succeeding through teamwork. This technology strategy will chart a course for the United States' military to strengthen its technological superiority amidst a global race for technological advantage.

To maintain the United States military's technological advantage, the Department will champion research, science, technology, engineering, and innovation. From the earliest days of this country the role of technology in shaping military concepts and providing for the defense of the nation has been essential. The demands of the present era call for new operational concepts, increasingly joint operations, and quickly fielding emerging science and technology opportunities.

Strategic competitors to the United States have greater access to commercial state-of-the-art technologies than ever before and can wield these technologies to be disruptive to America's interests and its national security. The challenges facing our country are both diverse and complex, ranging from sophisticated cyber-attacks to supply chain risks, and from defending against hypersonic missiles to responding to biological threats. In an ever shifting and fast-moving global environment, technological advantage is not stagnant and the Department cannot rely on today's technology to ensure military technological dominance tomorrow.

It is imperative for the Department to nurture early research and discover new scientific breakthroughs to prevent technological surprise. The Department must harness the incredible innovation ecosystem both domestically and globally in order to stay ahead of our competitors.

A. Innovation in an era of competition

The Department of Defense's Research and Engineering community welcomes cooperation and competition. As Secretary of Defense Austin said in his December 2021 speech at the Reagan National Defense Forum, "America isn't a country that fears competition. And we're going to meet this one with confidence and resolve." Competition has helped to bring about the United States' private sector and technology industry, both of which are the most vibrant in the world. Competition helped advance the space program, the seeds of modern information technology, and a myriad of derivative technologies that every day drive our national security and economic activity.

While the United States thrives on competition, we also excel at cooperation. The challenges facing warfighters will be solved through cooperation between the Government; the Defense Industrial Base; academia; Federally Funded Research and Development Centers (FFRDCs); University Affiliated Research Centers (UARCs); small businesses, new entrants, and startups; our international partners; and even with our competitors. Successful competition requires imagining our military capability as an ever-evolving collective, not a static inventory of weapons in development or sustainment. In many cases, effective competition benefits from sidestepping symmetric arms races and instead comes from the creative application of new concepts with emerging science and technology.

This era of strategic competition demands collective cooperation. Effective competition requires agility—in initiating new technology development, rapid experimentation in relevant mission environments, and rapid transition to the users.

B. Technology Strategy Pillars

Driven by clarity of mission, built upon strong foundations, and enabled by teamwork, the Department's technology strategy will enable the Department to innovate at speed and scale now and into the future.

This technology strategy will be anchored by three pillars:

Mission Focus: Leverage the United States' incredible technology innovation potential to solve the Department's tough operational, engineering, and mission-focused challenges.

Mission Focus requires a focus on warfighting outcomes with constant communication and iteration between research and development teams and mission owners, and solutions that cut across multiple weapon systems, Military Services, and Defense organizations. The OUSD(R&E) will balance pursuing mission-aligned technology with the need to conduct research and development in emerging sciences that can provide leap-ahead capabilities. The Department's technology strategy will be informed by emerging threats and empower the Department to achieve its mission objectives as laid out in the NDS. The OUSD(R&E) will work closely with the Military Services and Combatant Commands on the development and implementation of the Department's technology strategy.

Foundation Building: Set the foundation to attract and build a strong, talented future technical workforce that works in modernized laboratories and test facilities.

In this dynamic competitive environment, it is essential to invest in our people and infrastructure. The Department must modernize its system engineering and software engineering practices to promote continuous prototyping and experimentation. The OUSD(R&E) will break down barriers to success through policies that encourage innovation and risk taking.

Succeed through Teamwork: Maximize our asymmetric advantages by partnering with the larger innovation ecosystem, from industry to universities and to laboratories, allies and partners.

The Department must expand its relationships with the entire technology ecosystem across America and its allies and partners. Innovation has always been a strength of the United States, and the Department will harness that innovation. The Department must focus its developmental resources on unique capabilities needed by the military and quickly adopt the best commercial dual-use technologies. In the era ahead, the Department will diversify partnerships to bring in creative new entrants. Allies and partner nations are an asymmetrical advantage for the United States, and the Department will partner with nations that are aligned with the principles of the United States to jointly develop and deploy technology.

C. Critical Technology Areas

The OUSD(R&E) works closely with the Military Services, Combatant Commands, industry, academia, and other stakeholders to ensure that the Department's science and technology strategy addresses the key national security challenges—from rising seas to a rising China—that the United States faces today and will face in the future.

Three categories of technology areas recognize the more varied and complex environment for investment, development, and application of technology that characterizes the early 21st century. There are 14 critical technology areas vital to maintaining the United States' national security grouped into three categories. While many technologies may cross between these categories, these groupings represent the broad and different approaches that are required to advance technologies crucial to the Department. By focusing efforts and investments into these 14 critical technology areas, the Department will accelerate transitioning key capabilities to the Military Services and Combatant Commands. As the Department's technology strategy evolves and technologies change, the Department will update its critical technology priorities.

1. Seed Areas of Emerging Opportunity

Biotechnology
Biotechnology is an emerging engineering discipline that uses living systems to produce a wide range of technologies and capabilities. From fighting global pandemics and avoiding surprises to reducing logistics and sustainment costs and increasing energy efficiency, biotechnology can help change the way the Department conducts missions, performs in contested logistics environments, and adapts to major global changes.

Quantum Science
Quantum Science is the study of physical properties at small, even atomic, scales. Defense applications include atomic clocks, quantum sensors, quantum computing, and quantum networks. Quantum science promises to enable leap-ahead capabilities. Quantum computing can provide unprecedented computational speeds and help solve the Department's hardest analytical problems. Quantum sensors promise the ability to provide unprecedented accuracy in position, navigation, and timing. From more accurate

information to faster decision making, to significantly stronger encryption capabilities, quantum science has the promise to deliver cutting-edge technology.

Future Generation Wireless Technology (FutureG)
FutureG is a suite of emerging wireless network technologies enabled by DoD and commercial industry cooperation to enable military operations and ensure a free and open internet. As Fifth Generation (5G) wireless technology is adopted and provides building blocks for capability, the DoD will also look to FutureG for leap-ahead technologies to lead in creating future standards. The Department will invest in FutureG technology development to lay the groundwork for continued United States leadership in information technology, which is vital for maintaining our economic and national security.

Advanced Materials
Advanced materials explore innovative new materials and novel manufacturing techniques that can dramatically improve many of the Department's capabilities. Materials that have higher strength, lighter weight, higher efficiency, and can handle more extreme temperatures will have the potential to better protect our service members and enhance their ability to accomplish their missions.

2. Effective Adoption Areas – where there is existing vibrant commercial sector activity

Trusted AI and Autonomy
Artificial Intelligence (AI) is the software engineering discipline of expanding capabilities of software applications to perform tasks that currently require human intelligence. Machine learning is an engineering subfield of AI that trains software models using example data, simulations, or real-world experiences rather than by direct programming or coding. Autonomy is the engineering discipline that expands robots' abilities to perform tasks while limiting the need for human interaction. AI holds tremendous promise to improve the ability and function of nearly all systems and operations. Trusted AI with trusted autonomous systems are imperative to dominate future conflicts. As AI, machine learning, and autonomous operations continue to mature, the DoD will focus on evidence-based AI-assurance and enabling operational effectiveness.

Integrated Network Systems-of-Systems
Integrated Network Systems-of-Systems technology encompasses the capability to communicate, provide real-time dissemination of information across the Department, and effective command and control in a contested electromagnetic environment. Integrated Network Systems-of-Systems capability must enable engagements by any sensor and shooter, with the ability to integrate disparate systems. An interoperable network that leverages emerging capabilities across the electromagnetic spectrum such as 5G, software defined networking and radios, and modern information exchange techniques will allow the Department to better integrate many diverse mission systems and provide fully networked command, control, and communication that is capable, resilient, and secure.

Microelectronics
Microelectronics are circuits and components that serve as the "brain" to human-made electronic functional systems. Virtually every military and commercial system relies on microelectronics. Diminishing microelectronics manufacturing in the United States and supply chain concerns have highlighted national economic and security risks. Working closely with industry, academia, and across the Government, the Department is addressing the need for secure microelectronics sources and will leverage state-of-the-art commercial development and production for defense microelectronic solutions.

Space Technology
Space technologies include space flight, space communication and other technologies needed to maintain space operations. With rising threats and increasing dependence on space-based systems, the Department's space strategy must shift away from exquisite satellites to a more robust and proliferated architecture. Novel space technologies are necessary to enable resilient cross-domain operations. The space strategy must incorporate technologies that enhance the Department's adaptive and reconfigurable capabilities in space situational awareness, space control, communication path diversity, on-orbit processing, and autonomy.

Renewable Energy Generation and Storage
Renewable energy generation and storage includes solar wind, bio-based and geothermal technologies, advanced energy storage, electronic engines, and power grid integration. Renewable energy generation and storage promises to decrease warfighter vulnerability and deliver new operational capabilities for the Department. From more efficient batteries to diversifying energy sources and reduced fuel transportation risks, renewable energy generation and storage will add resilience and flexibility in a contested logistics environment.

Advanced Computing and Software
Advanced computing and software technologies include supercomputing, cloud computing, data storage, computing architectures, and data processing. Software is ubiquitous throughout the Department, but the speed at which software develops outpaces the Department's ability to stay up to date. The Department must rapidly modernize its legacy software systems with resilient, affordable, and assured new software that has been designed, developed, and tested using processes that establish confidence in its performance. The Department must migrate to a Development-Security-Operations (DevSecOps) approach in its software development and evolve to a model of continuous development, continuous test, and continuous delivery. The Department must leverage modular open system architecture approaches to isolate hardware from software and enable rapid upgrades to secure processors.

Human-Machine Interfaces
Human-Machine Interface refers to technologies related to human-machine teaming and augmented and virtual reality. Rapid advancements in this technology will have a multitude of benefits for our service members. Highly immersive realistic training environments provide real-time feedback to enhance warfighter performance. Intuitive

interactive human-machine interfaces enable rapid mission planning and mission command by providing a common operational picture to geographically distributed operations.

3. Defense-Specific Areas

Directed Energy
Directed Energy Weapons utilize lasers, high power microwaves, and high energy particle beams to produce precision disruption, damage, or destruction of military targets at range. Directed energy systems will allow the Department to counter a wide variety of current and emerging threats with rapid responses and engagement at the speed of light. High-power lasers and high-power microwave technologies both offer new ways to counter diverse sets of threats.

Hypersonics
Hypersonic systems fly within the atmosphere for significant portions of their flight at or above 5 times the speed of sound, or approximately 3700 miles per hour. Hypersonics dramatically shorten the timeline to strike a target and increase unpredictability. While strategic competitors are pursuing and rapidly fielding advanced hypersonic missiles, the DoD will develop leap-ahead and cost-effective technologies for our air, land, and sea operational forces.

Integrated Sensing and Cyber
To provide advantage for the joint force in highly contested environments, the Department must develop wideband sensors to operate at the intersection of cyber space, electronic warfare, radar, and communications. Sensors must be able to counter advanced threats and can no longer be stove-piped and single function.

D. Bridge to the Future

The OUSD(R&E) will develop critical technologies, rapidly prototype them, and conduct continuous campaigns of joint experimentation to improve on those technologies and deliver capabilities. More swiftly transitioning technology from invention to successful fielding will require changes across the Department. The OUSD(R&E) will support reforms to the Department's resource allocation processes and will pursue novel mechanisms and alternative pathways to rapidly field technologies. The OUSD(R&E) will engage a community of stakeholders to work to develop appropriate pathways to field relevant technologies supporting required joint warfighting capabilities.

With knowledge, clarity of purpose, real commitment to the innovation ecosystem, and cooperation, the Department will be able to field more rapidly the technologies needed to support warfighting capabilities now and in the future. I am honored to lead the Department's research and engineering community comprised of the most talented civic-minded scientists, engineers, and professionals through these exciting times.