

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING FOR ADVANCED CAPABILITIES







BRIDGE THE DIVIDE BETWEEN TECHNOLOGY DISCOVERY AND FIELDED OPERATIONS

Introduction	3
LETTER FROM	
TERRY EMMERT	
Section One	4-8
PROTOTYPES AND	
EXPERIMENTS	
	The state of
Section Two	9-18
ENGINEERING	
Section Three	19-25
TEST RESOURCE	
MANAGEMENT CENTER	

Introduction A Letter from Terry



TERRY EMMERT

ACTING DIRECTOR OF DEFENSE RESEARCH & ENGINEERING FOR ADVANCED CAPABILITIES DDR&E (AC)

AND PRINCIPAL DEPUTY DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING FOR ADVANCED CAPABILITIES PD DDR&E (AC) We all take a great many memories from 2021, not least of which are the pandemic, welcoming a new presidential administration, and the inexorable advancement of China as a strategic competitor. There has been so much change and so much work to do that the year has simply flown by. Through it all, the depth and breadth of accomplishment your selfless work has engendered is remarkable. As Elbert Hubbard once observed, "the world now moves so fast that those who say it can't be done are generally interrupted by those doing it."

You'll see ample evidence of that in this Newsletter. In Prototypes & Experiments, for example, a new way to accelerate joint experimentation has been established in the Rapid Defense Experimentation Reserve program. Starting from zero, in a matter of months the P&E team has identified for experimentation next year 32 new technological approaches that address critical warfighting capability gaps. The Engineering team held the first-ever Mission Engineering Forum with industry partners and also completed multiple Independent Technical Risk Assessments on major acquisition programs. TRMC has developed a prototype test capability to generate neutron radiation required for nuclear survivability and vulnerability testing without needing to use enriched nuclear materials.

That's not even everything that's in this Newsletter, to say nothing of the thousands of AC successes and achievements that are not included here. It's important to recognize that because what you do matters. Our Service members need the solutions you provide, as our adversaries are not standing still. I'm humbled to work with such a talented, dedicated, and productive team. I can't wait to see what you accomplish next year.

All the best, Terry



PROTOTYPES AND EXPERIMENTS

P&E Mission: Operationalize Advanced Concepts and Technologies to rapidly provide our Joint warfighters with overmatch capabilities aligned with the National Defense Strategy and Modernization areas.

Rapid Defense Experimentation Reserve (RDER)

Expanding and Aligning Defense Experimentation

Prototypes & Experiments has developed and managed the Rapid Defense Experimentation Reserve (RDER) – established in April 2021 by the Deputy Secretary of Defense, Dr. Kathleen Hicks – to facilitate more rapid modernization. RDER has the goal of expanding inter-service experimentation in a structured, multi-year campaign of learning. Capabilities that graduate from the RDER program will support joint requirements with the intent to be fielded across multiple services. Proven through experimentation, RDER capabilities will introduce groundbreaking new systems and approaches to fight Joint battles.

In addition to establishing the RDER program, Prototypes & Experiments also conducted the first call for proposals in the summer of 2021. From June to August, Services, Combatant Commands, and Defense Agencies submitted more than 200 proposals to experiment with advanced technologies that might solve some of the key issues facing US forces in competition with peer and near-peer adversaries. The most successful proposals reached the Deputy's Management Action Group, chaired by the Deputy Secretary of Defense Kathleen Hicks, where the best of breed were selected to be demonstrated at key military exercises starting in the fall of 2022.

The next RDER proposal call cycle will begin in January 2022 and will be open to traditional and non-traditional industry, academia, small-business, and US government entities.



Capability Prototypes Innovation Outreach, Discovery, and Demonstration Engaging with the Non-Traditional US Defense Industry

ROBUST ENGAGEMENT

In 2021, Capability Prototypes executed the Department's vision for robust engagement across the innovation ecosystem. Capability Prototypes' programs connect one-to-one with innovators not typically engaged in the defense industry by introducing them to potential DoD transition partners.

Small-businesses, start-ups, and academia in the United States produce some of the most cutting edge research, technology, and capabilities, which often go untapped by the Department. Innovation Outreach, Discovery, and Demonstration are opportunities to find and support these non-traditional entities as they navigate working with the Department.



Innovation Outreach engagements will continue in 2022 and beyond to scout more opportunities for collaboration with non-traditional sources.

DISCOVERING INNOVATION

Through a continuous series of quarterly public-facing Innovation Outreach engagements and monthly Innovation Discovery and Demonstration venues, Capability Prototypes explored 1,077 innovative ideas and demonstrated 219 technologies applicable to Joint requirements to 815 government representatives. Of these, 73 technologies were selected by the Services or other DoD organizations for follow-on activity including testing, procurement, and transition. Additionally, these Innovation Discovery and Demonstration venues mentored 136 small or start-up businesses on the needs of the DoD end users, enabling these new partners to innovate better and faster.



Foreign Comparative Testing (FCT)

Collaborating with International Partners

BUILDING RELATIONSHIPS

The Foreign Comparative Testing (FCT) Program finds, assesses, and fields world-class products being utilized by US allies around the globe. The office of Mission Prototypes – where the program resides – frequently engages with allies to test, evaluate, and acquire technologies that partner militaries already utilize to solve their own unique, global problems. Foreign Comparative Testing is an important program for building relationships with partner nations, sharing research and technology, and enabling global competition.

Despite yearlong international travel restrictions, the office of Mission Prototypes conducted regular engagements with 20 different partner nations. Through these engagements, the team reviewed around 400 vendor submitted technologies and conducted individual meetings with over 180 foreign companies to discuss technologies of potential interest to the DoD. Additionally, Mission Prototypes reviewed 69 proposals from the Armed Services and US Special Operations Command seeking \$75M in FCT funding to test and evaluate 118 different technologies from 26 countries starting in FY22. Lastly, Mission Prototypes closed out 16 FCT projects. Of the 14 that successfully completed testing, 13 (93%) transitioned to follow-on activity supporting DoD development and acquisition programs. These successfully tested technologies will support the unique challenges that the US Armed Services face around the world.





DEPUTY DIRECTOR FOR ENGINEERING

The mission of the Office of the Deputy Director (DD) for Engineering is to solve engineering problems, propagate engineering best practices, and connect the engineering community, with the ultimate goal of facilitating the rapid transition of technology to the warfighter. With approximately 230 defense acquisition and intelligence professionals, the office includes the directorates of Developmental Test, Evaluation, and Assessments (DTE&A), Engineering Policy and Systems (EP&S), and Mission Integration (MI), as well as the Joint Hypersonics Transition Office (JHTO) and the Strategic Intelligence and Analysis Cell (SIAC).

Developmental Test, Evaluation, and Assessments

Expert Risk Assessment and Mitigation

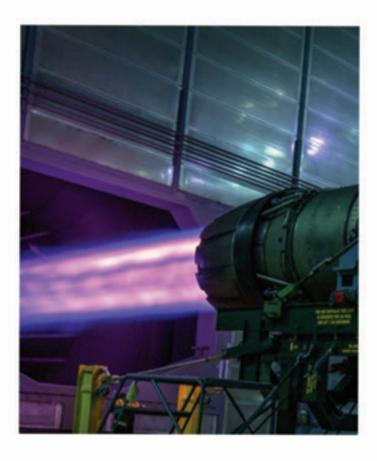
Developmental Test, Evaluation, and Assessments (DTE&A) provides independent systems engineering (SE) and test and evaluation (T&E) expertise to ensure the Department delivers future force capabilities to the warfighter that are timely, reliable, and able to be integrated across Joint organizations. In FY21 DTE&A focused on two areas of emphasis: Major Defense Acquisition Program (MDAP) support and advancing the T&E state of practice.

DTE&A provided SE and T&E assessments and evaluations to support major programs. DTE&A accurately evaluated system performance and technical engineering integration risks, complementing and reinforcing the analyses of DoD programs as they executed Adaptive Acquisition Framework pathways. DTE&A's primary assessment process was the Independent Technical Risk Assessment (ITRA). As required by Title 10 U.S.C. 2448b, DTE&A completed three MDAP ITRAs and supported two Service-conducted ITRAs approved by the USD(R&E) in FY21. These assessments helped ensure the delivery of trusted and reliable systems supporting U.S. warfighters, while managing acceptable technical risk.

In addition, DTE&A delivered 10 independent Developmental Test Assessments and two Developmental T&E Sufficiency Assessments to OSD organizations and Service Acquisition Executives, informing production and fielding decisions. DTE&A assessments provided data-driven analysis and accurately evaluated system performance and T&E integration risks to inform critical acquisition and warfighting capability decisions. The office supported the development, review, and approval of 11



SUPPORTING U.S. WARFIGHTERS

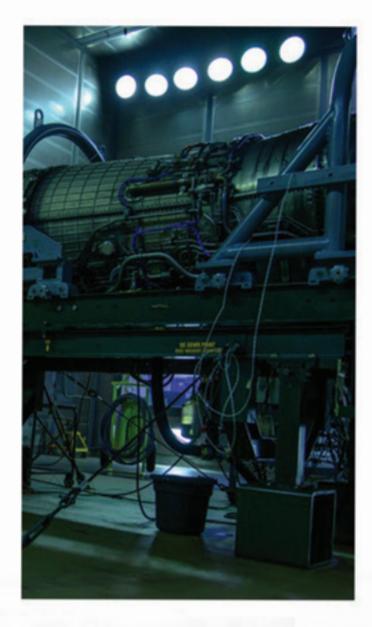


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Developmental T&E Strategies within program T&E Master Plans. Through participation in T&E and SE program working groups, DTE&A provided test strategy reviews that helped programs develop efficient T&E strategies.

Future war outcomes depend on early delivery of advanced warfighting capabilities. In FY21, DTE&A expanded early mission-aligned testing by advancing the state of SE and T&E practice through the Integrated Decision Support Key–Evaluation Framework (IDSK-EF). The IDSK-EF focuses T&E operational and technical capability evaluation to inform decision making throughout the concept-to-fielding continuum. The IDSK-EF is closely coupled with the output of the mission engineering process. The IDSK-EF provides analytical rigor and consistency to test design, capability evaluation, and decision support.

DTE&A established multiple panels and workshops focused on improving information sharing across the T&E and SE communities, including the Scientific Test and Analysis Techniques (STAT) Implementation Panel, which promotes the use of



statistical techniques to support test design;
Autonomous Defense Systems T&E working
groups, which focus on testing of autonomous
systems; and T&E in Artificial Intelligence
workshops. In addition, DTE&A drafted a cyber
T&E activity-based model for inclusion in the new
DoD Enterprise T&E Guidebook as a Cyber T&E
Focus Area, and an accompanying Cyber T&E
Companion Guide that provides "how-to"
guidance for cyber engineering and testing.

These DTE&A accomplishments supported delivering advanced capabilities to the warfighter and supporting the National Defense Strategy. To learn more about DTE&A accomplishments, deliverables, and focus areas, visit the Developmental Test, Evaluation, and Assessments web page.

Engineering Policy and Systems **Market Systems Standards for Engineering Best Practices **Market Systems Systems Standards for Engineering Best Practices **Market Systems Systems

INNOVATIVE PRINCIPLES

Engineering Policy and Systems (EP&S) promotes the use of innovative and modern engineering principles and techniques to get the right capabilities to the warfighter at the right time. EP&S creates policy, guidance, and standards that propagate engineering best practices; establishes and develops communities of practice that connect the engineering community to solve cross-cutting engineering challenges; strengthens knowledge, skills, and abilities and defines the education, training, experience, and proficiency standards to develop the engineering workforce; and provides engineering expertise to support OUSD(R&E) priorities.

The EP&S Systems Engineering (SE) team integrated ongoing independent modernization efforts in four Focus Areas: digital engineering, mission engineering, software, and modular open systems approach (MOSA). In addition, SE leveraged the Defense Acquisition Workforce Development Account to identify policy and workforce modifications to modernize SE, leading

to a partnership with the Systems Engineering Research Center (SERC) to assess ongoing research for SE Modernization Strategy, Roadmaps, and Bodies of Knowledge.



The EP&S Specialty Engineering team catalyzed teaming and consensus building on policy, guidance, standards, knowledge, and training and education to advance engineering for reliability and maintainability, manufacturing and quality (M&Q), system safety, and human systems

integration (HSI). Achievements in FY21 included establishing the M&Q Body of Knowledge and the HSI Community of Practice in collaboration with partners in DoD, industry, and academia.

The EP&S Software Engineering team led three strategic efforts in FY 2021: the DoD Software Science and Technology (S&T) Strategy; Resilient Command and Control Bus; and Digital Talent Management. These efforts support modernization and improve the DoD software workforce. The Software team led the S&T software modernization Senior Steering Group, which developed and refined the DoD Software S&T Strategy. This strategy addresses goals and focus areas to bridge the gap between software S&T and acquisition to minimize time to operational use.

The EP&S Engineering Tools and Environments (ETE) team supported a model and simulation gap assessment for hypersonics and produced a repeatable methodology usable in other disciplines and areas of interest. ETE continued advancing the engineering practice shift to virtual, building interactive and current bodies of knowledge through vibrant communities of practice in digital engineering and modeling and simulation. ETE delivered a digital ecosystem and evolving requirements for the digital ecosystem to Mission Integration for use in conducting mission engineering analysis.



REPEATABLE METHODOLOGY USABLE IN OTHER DISCIPLINES AND AREAS OF INTEREST

The EP&S Policy and Workforce team published two DoD Instructions in FY 2021: DoDI 5000.88, "Engineering of Defense Systems" and DoDI 5000.89, "Test and Evaluation." These instructions replace their enclosures in the previous DoDI 5000.02, "Operation of the Defense Acquisition System." In addition, Policy and Workforce supported publication of the Mission Engineering Guide, an essential Department resource that describes mission engineering attributes, methodology, benefits, and best practices; ITRA Execution Guide, which assists the Department in preparing ITRAs (a statutory requirement at Milestone A and B); and the Systems Engineering Plan (SEP) Outline, Version 4.0, which assists programs of record in preparing SEPs in accordance with statute, DoD policy, and best practice.

The Defense Standardization Program Office (DSPO) is the Department's single, unified standardization program to promote interoperability, reduce total ownership cost, and sustain readiness. In 2021 it provided users with access to more than 28,000 active standardization documents, including 2,865 active international standardization agreements and 44 MOSA-enabling documents. DSPO led the NATO Standardization Management Group writing team, supported by Canada, the United Kingdom, and France, to publish new Intellectual Property Rights Policy for NATO Standardization Documents.



Mission Integration

Focusing Technology Investment on the Most Important Joint Missions

MODERNIZATION AND INNOVATION

Mission Integration (MI) provides analytical engineering support to develop mission-based inputs for the requirements process, improve Joint Force capability integration and experimentation, and inform the development and maturation of joint requirements and operational plans. In FY21, MI expanded OUSD(R&E)'s involvement in the military requirements process, completed six mission engineering studies, executed an industry outreach program, published the Mission Engineering Guide, and shaped missile defense policy.

MI expanded R&E's support to the military requirements development process, assisting the Joint Requirements Oversight Council (JROC) in

develop a Joint Capabilities Integration and Development System engagement process that resulted in R&E executives providing technical advisory support to more than 50 3-star Joint Capabilities Boards and 4-star JROC sessions. The CM team also pioneered R&E's first participation in the Joint Staff's Globally Integrated Wargame, a series of annual events designed to test and push the boundaries of future Joint requirements and to influence DoD-wide modernization and innovation. The ME team took the lead on Mission Engineering Forum



industry outreach, holding the first

establishing joint requirements that are grounded

threat-relevant timelines. MI's Concept Maturation

(CM) team worked across the R&E organization to

in technology that can be fielded in feasible and

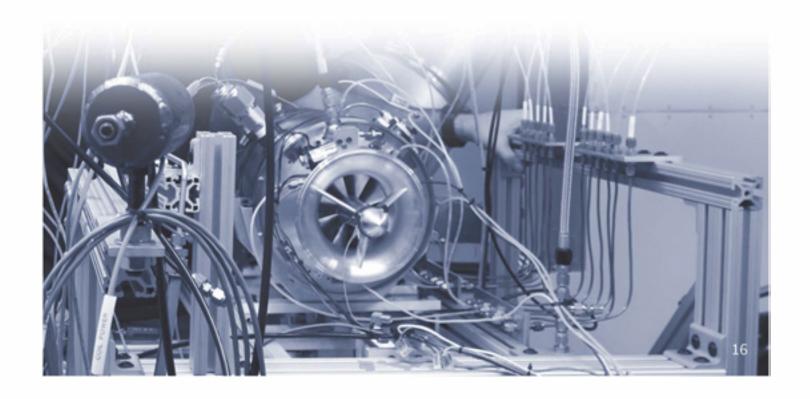
MI's Mission Engineering (ME) team conducted studies on technologies prioritized by the warfighter Combatant Commands (CCMDs), Joint Staff, Services, and OSD. The results of these analyses-in hypersonics, directed energy, electromagnetic spectrum operations, and position, navigation, and timing - inform R&E Modernization's technology roadmaps and support the transition of mature technologies to programs of record. In addition, in coordination with EP&S, ME published the Mission Engineering Guide.

ME planned and executed the FY21 Advanced Capabilities-Joint Staff Workshop, which invited senior stakeholders and warfighters to collaboratively set the agenda for study topics that will shape future force analysis. The ME team took the lead on industry outreach, holding the first Mission Engineering Forum bringing together



REQUIREMENTS ARE GROUNDED IN TECHNOLOGY THAT CAN BE FIELDED IN FEASIBLE AND THREAT-RELEVANT TIMELINES

Reserve campaign of learning.



Joint Hypersonics Transition Office

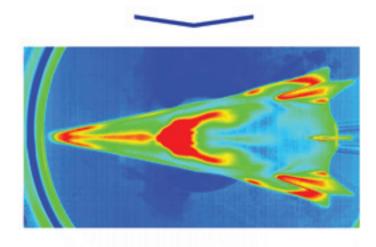
Integrated S&T Strategy for Hypersonics



The USD(R&E) established the Joint Hypersonics Transition Office (JHTO) in April 2020 pursuant to guidance in the 2020 National Defense Authorization Act. JHTO's responsibilities include developing an integrated S&T strategy for hypersonics, establishing a university consortium for applied hypersonics research, enhancing the national hypersonic workforce necessary to support accelerated development and fielding of hypersonic capabilities, and engaging with foreign allies. JHTO led the creation of the Australia-United States hypersonics strategy, which the DoD and Australian counterparts signed in 4th quarter FY21. The JHTO achieved several milestones in FY21, its first full year in existence.

JHTO is funding 38 projects to address critical capability needs for hypersonic weapons. At a value of over \$57 million, the projects support the MDA's Glide Phase Intercept, the Air Force hypersonic programs, and the Navy and Army Common Hypersonic Glide Body. JHTO awarded the projects to government laboratories and industry partners, spanning seven technical areas such as high-temperature materials; ordnance; and navigation, guidance, and control.

JHTO is committed to ensuring the United States develops an affordable hypersonic cruise missile (HCM). To that end, JHTO is funding the Boeing HyFly2 effort to ensure the United States possesses an HCM that is compliant with naval aircraft. JHTO initiated the HyFly 2 Risk Mitigation program near the end of FY20 and conducted a System Requirements Review and three Technical Interchange Meetings in FY21. The program is driving down technical risk for the HyFly 2 hypersonic missile concept by including Joint-Service expertise in design, analysis, and test efforts, which will culminate in an engine Preliminary Design Review in early FY23.





continued from page 17

In 1st quarter FY21 JHTO established the Systems Engineering Field Activity (SEFA) at the Naval Surface Warfare Center in Crane, Indiana. The SEFA has three main focus areas: SE, program integration, and workforce development. Workforce development initiatives include sponsored research, curriculum development, and engagements with industry to create a growing pipeline of highly technical talent to enter the hypersonics workforce.

Also in 1st quarter FY21, JHTO established the University Consortium for Applied Hypersonics (UCAH), which provides a hub for government, academia, industry, and national laboratory collaboration in pursuit of hypersonics S&T objectives and development of the U.S. hypersonics workforce. Managed by the Texas Engineering Experiment Station (TEES), a research center affiliated with Texas A&M University, the UCAH includes more than 80 universities, 90 industry partners, 8 national labs and federal funded research and development centers, university-affiliated research centers, and more than 1,100 participating researchers and students. TEES formed an advisory structure and committees dedicated to workforce development, industry and national lab engagement, and technology transition.

JHTO funded 17 research projects through the UCAH with a 3-year value of \$25.5 million. The initiative significantly furthered the Department's S&T and workforce development goals. The UCAH hosted Fall and Spring Forums and eight technical seminars, engaging experts from across the hypersonics enterprise and facilitating the collaborative environment JHTO needs to address hypersonics challenges.



TEST RESOURCE MANAGEMENT CENTER

Test infrastructure across the Department has aged significantly since the end of the first Cold War. To accelerate research and development in a near-peer competition, the Test Resource Management Center (TRMC) is pursuing test infrastructure investments in eight strategic Portfolios: Hypersonics, Directed Energy, Cyber, Electronic Warfare, Nuclear Modernization Space Systems, Autonomy and Artificial Intelligence, and Multi-Domain Integration. Examples of key efforts follow.

Hypersonics

Supporting Next-Generation Hypersonic Systems

DRAGONFIRE

The DragonFire project is overhauling our Nation's high-temperature test capabilities to better assess new aeroshell materials for offensive and defensive hypersonic systems (i.e., next-generation interceptors) as well as nuclear modernization. The new arcjet test bays will increase our test throughput five-fold, enabling our Nation to experiment and prototype different materials which will optimize weapon performance (missile range, maneuverability, and survivability).

PHOENIX

The Phoenix project is building a new hypersonic test facility to replicate flow conditions for air-breathing hypersonic systems (scramjet engines) with the goal of being able to "fly the hypersonic mission on the ground."

SKYRANGE

The SkyRange project is retrofitting long-duration, high-altitude unmanned aerial systems (RQ-4 Global Hawks and MQ-9 Reapers) with telemetry, optics, and other instrumentation to support long-range hypersonic flight testing.





Directed Energy

IMPROVING OPERATIONAL REALISM

In September 2021, culminating years of advocacy and Department-wide stakeholder engagement by the TRMC, the Commander, United States Space Command signed out a memorandum designating White Sands Missile Range, New Mexico; Point Mugu Sea Range, California; and Starfire Optical Range (Kirtland Air Force Base), New Mexico as Special Use Space Ranges (SUSRs). The establishment of SUSRs significantly expands available windows for the test and evaluation of directed energy systems and enables more operationally realistic engagement scenarios for high-energy laser testing.

THE ESTABLISHMENT OF SUSRs SIGNIFICANTLY EXPANDS AVAILABLE WINDOWS FOR TESTING DIRECTED ENERGY SYSTEMS

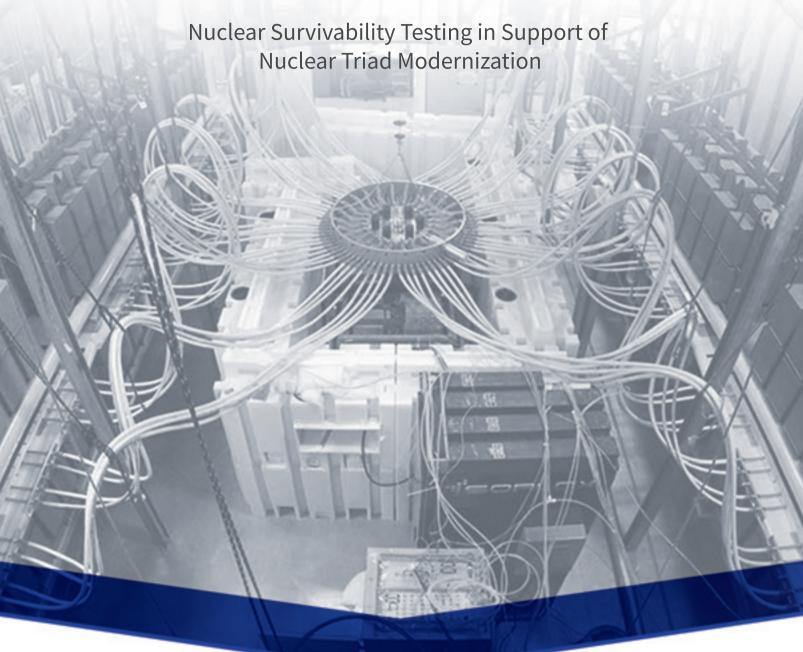
Cyber

ADVANCING CYBER RANGE TESTING

In July 2021, supported by the Army Contracting Command-Orlando, we established a 10-year \$2.4 billion contract to advance cyber range testing, including cyber event planning and execution, cyber range modernization and operations, and cyber test data analysis across the National Cyber Range Complex (NCRC). With a pool of 15 awardees – including 10 small businesses – this contract provides a competitive vehicle to leverage a diverse mix of industry performers. In a departure from the previous single-prime contract, awardees will compete for individual task orders, enabling the government to quickly and affordably incorporate technology advances at existing and future NCRC locations.



Nuclear Modernization



EXPANDING CAPABILITY

We have developed a prototype test capability that can generate ultra-short pulsed neutron radiation in patterns similar to a fusion-based nuclear detonation without the use of special nuclear material. The Neutron Dense Plasma Focus (NDPF) prototype has demonstrated a technologically viable, more cost-effective alternative to generating the neutron radiation required for nuclear survivability and vulnerability testing without needing to use highly enriched nuclear materials, avoiding the increase costs and limitations of storing, transporting, and securing uranium.

A technologically viable, more cost-effective alternative



Autonomy and Artificial Intelligence

Next-Generation Data Analysis Systems

REDUCING BARRIERS TO ADOPTION

We are collaborating with the Department of Transportation on how to improve testing safety and assess user trust in autonomous systems testing. By developing test methodologies and identifying best practices for the planning, execution, control, and assessment of autonomous unmanned systems test events, we are working toward the goal of establishing common test tools for use by commercial and military developers, reducing barriers to adopting autonomous vehicles in both public and private sectors.

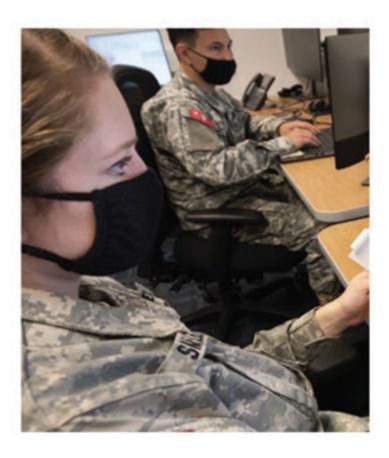
ACCELERATING DATA PROCESSING

We are developing next-generation data analysis systems that incorporate big data analytics to accelerate post-test analysis. The Cloud Hybrid Edge-to-Enterprise Evaluation and Test Analysis Suite (CHEETAS) is an enterprise solution for

improving data analysis that provides evaluators with high-quality, reliable data in a significantly reduced timeframe in order to identify and correct issues earlier and at a lower cost than legacy data analysis capabilities. CHEETAS uses artificial intelligence and machine learning techniques to significantly decrease the labor of subject matter experts determining the validity of the data collected during a test. Recent test events have demonstrated impressive gains in the speed of data analysis when using CHEETAS. For example, during a 419th Flight Test Squadron event at Edwards Air Force Base, CHEETAS reduced the time to ingest, process, convert, and tag data from hours to minutes.

In another example, CHEETAS supported the Navy in cutting the time to process data collected during a radar test from weeks to days.



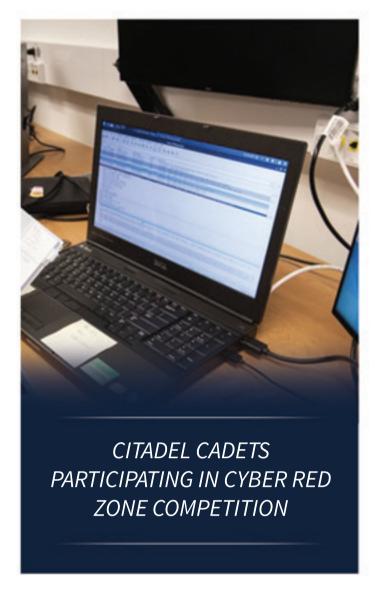


Test and Evaluation Workforce

BUILDING TOWARD T&E WORKFORCE 2030

The TRMC National Cyber Range Complex (NCRC) in Orlando hosts Cyber Red Zone, a biannual capture-the-flag style competition. This year, for the first time, teams of Citadel cadets joined the event from NCRC Charleston, gaining red team skills in a dynamic learning environment. Attracting fresh talent through targeted opportunities helps ensure the readiness of the future test and evaluation workforce.

In June 2021, we opened the National Cyber Range Complex Unclassified (NCRC-U) test and training facility at the Georgia Cyber Center in Augusta, Georgia. A key component of our T&E Workforce 2030 campaign, the NCRC-U offers an innovation-focused environment with multiple classrooms and a common area for academic engagement, collaboration, and practical experience. classrooms and a common area for academic engagement, collaboration, and



partnered with several universities to conduct cyber research and testing, including the development of a wireless autonomous vehicle test capability in collaboration with Auburn University, and provided learning opportunities for several interns and cyber operators this summer.

During summer 2021, we selected 40 science, technology, engineering, and mathematics interns from 19 universities for a 10-week experiential learning program at 12 Major Range and Test Facility Base locations. We plan to continue the intern program in future years, with the objective of inspiring interns to pursue DoD test and evaluation careers and ultimately bolstering the test community workforce.



Advanced Capabilities: delivering the *right capabilities* at the *right time*.



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