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Interview by Heather Wojton, Ph.D., Chad Bieber, Ph.D., and Ryan Norman

Last year Congress appropriated additional funds to the test and evaluation (T&E) community to improve the existing infrastructure the U.S. military uses to evaluate weapon system performance. Congress stipulated that these infrastructure improvements must align to the National Defense Strategy (NDS). Recently, we had the opportunity to discuss the strategy for aligning the T&E infrastructure investments to the NDS with Mr. Dave Duma, the Principal Deputy Director, Operational Test and Evaluation, and Mr. James Faist, Director of Defense Research and Engineering for Advanced Capabilities.

The NDS outlines three goals we must achieve to secure the competitive advantage against our near-peer adversaries: building a more lethal force, strengthening alliances and attracting new partners, and reforming the Department's business practices for greater performance and affordability. How is the T&E community positioning the Department to achieve these goals?

Faist: We have organized the Office of Research & Engineering (R&E) to directly align to the NDS modernization priorities. There are now R&E Assistant Directors (ADs) that have been given the task to develop and manage investment roadmaps that prioritize investments based on advancing mission capabilities in each of our Nation's critical technology areas. Each roadmap has a T&E section that the Test Resource Management Center (TRMC) is helping the AD define and execute. Prioritizing our efforts vis-à-vis these defined needs results in major investments in hypersonic test infrastructure and directed energy test infrastructure, as well as investments in artificial intelligence, autonomy, cyber, big data, and other areas.

Duma: Regarding strengthening alliances and attracting new partners, the Office of the Director, Operational Test and Evaluation (DOT&E) manages the International T&E program for the Department. We have 11 bilateral agreements with allied nations and one multi-national agreement with the Five Eyes countries. We are currently working on establishing bilateral agreements with South Korea and Japan. The biggest effort being negotiated is a multinational agreement for testing with France, Germany, Italy, the United Kingdom, and the United States with a provision to add other allied nations in the future.

To address reforming the Department business practices for greater performance and affordability, DOT&E initiated an effort to streamline content in Test and Evaluation Master Plans (TEMPs) to reduce the administrative burden. Several pilots are currently underway to evaluate the streamlined process.

Faist: R&E is also working on pilot programs that emphasize digital engineering and digital twin architecture throughout the entire systems engineering life cycle of programs. We expect digital engineering to increase efficiency and, along with continued emphasis on system architectures, reduce the effort and cost required to achieve those efficiencies.

The Under Secretary of Defense for Research and Engineering, Dr. Michael Griffin, identified a list of emerging technology areas the Department of Defense (DoD) must acquire to ensure its advantage over near-peer adversaries, including hypersonics, directed energy, artificial intelligence and autonomy, and cybersecurity (among others). Which of these emerging technologies poses the greatest infrastructure challenges to the T&E community? How is the T&E community working to overcome these challenges?

Faist: I see the priorities as hypersonics and directed energy, which are, fundamentally, physics problems. The other areas are cross-cutting technologies with elements in many different areas and are, fundamentally, problems of complexity. Speed and capacity are our limiting factors today. We lose valuable time if there is not enough infrastructure to support test requirements. To overcome these challenges, we have aligned the TRMC to support the R&E modernization roadmaps, so we better forecast the infrastructure needs required to test these emerging technologies. Our strategic forecast of test infrastructure needs drives our investments in models and simulations, ground test capabilities, and open-air ranges.

Are there particular T&E investments needed to support hypersonics and directed energy?

Faist: Yes. Hypersonics involves really long ranges—how do you test at 1,000 km away or more? At the other end of testing, our hypersonic wind tunnels are overbooked. We are on track to solve the long range problem, including investing in an unmanned aerial vehicle-based "Sky Range" that can put instrumentation in place within hours for a test anywhere we can get airspace. We are still working on ways to improve our current wind tunnels and possibly bring some old tunnels out of mothball status. Directed energy brings unique challenges of measuring performance and conducting the test safely. We need to characterize energy on target with instrumentation that can withstand the effects of directed energy weapons, and we need to ensure the safety of the personnel testing those weapons. In addition, when we are testing directed energy weapons, we must understand the risk to other systems, such as satellites, so we mitigate damage to systems outside of the test.

Duma: Hypersonics and directed energy are doing okay. There are challenges, but we know what those challenges are and have good ideas of how to overcome them. Artificial intelligence, autonomy, and machine learning are fuzzier and ethical problems crop up occasionally. Uber, for example, has stepped back and is re-evaluating how it tests software when those tests involve thousands of pounds of metal in close proximity to people. We often get asked how we will test artificial intelligence. I think that is the wrong question, we will test equipment that is using artificial intelligence. We are focused on evaluating the degree to which units equipped with systems that employ artificial intelligence can accomplish their mission.

Faist: The concepts needed for testing artificial intelligence aren't new—nuclear weapons and nuclear power testing posed questions of public safety out of which independent verification and validation concepts were developed. We will need to develop our own tools to independently test and verify these systems; tools likely using artificial intelligence and machine-learning algorithms.

Duma: The same is true of cyber. We get really good information from penetration testing by our Red Teams, but it is very manually intensive and there is far more software in the world than there are Red Teams. We need to develop automated tools to do what Red Teams do today to free up our teams to do more creative work on the harder problems that only humans can replicate.

Thinking beyond DoD, cybersecurity is a real game changer, and one that we need a national initiative to address. The continental U.S. is being attacked daily. These attacks are stealing technologies developed in our research labs and universities. Loss of these technologies is eroding the technological edge that the United States relies on – we depend on a technologically superior force to counter adversaries that can put more troops in play.

Faist: We need to leverage efforts in the commercial sector, such as the banking industry, and transfer that technology to support this national effort. A difference from the commercial sector, the DoD does have a unique role in offensive cyber warfare. The DoD should focus more effort on offensive cyber

capabilities going forward, and continue to grow our relationships with the private sector to ensure the Nation has a very strong cyber defense.

The Department is working to deliver performance at the speed of relevance by adopting rapid, iterative approaches to system development and fielding, and exercising the new middle-tier acquisition pathways. How can we ensure that programs that adopt these rapid, iterative approaches and pathways undergo adequate testing without introducing program delays? Are there infrastructure changes that would improve the efficiency of test and evaluation?

Duma: The T&E community should be involved early in the requirements development and experimentation stage to inform what the requirements should be. We need to build in automated data collection and build more tools to collect and process data automatically.

Faist: We should develop automated test capabilities early in the rapid development cycle and use them to continuously test and review system performance with a focus on quality and cybersecurity from day one. The commercial software world does this, but we in the DoD wait until later in the development cycle to add on testing and security.

In the DoD acquisition world, it seems programmatics drive decision-making, shaping programs based on schedule and cost instead of the technical baseline. We need to reverse that and focus on engineering to drive and define the technical baseline with the business aspects supporting those decisions.

All of the NDS areas share a common need to improve how we test software. What are you doing from an infrastructure and evaluation perspective to improve our ability to test software?

Duma: The Congressional appropriators increased the DOT&E budget last year to make investments in the DOD testing infrastructure to be able to adequately test the advanced technology areas identified in the NDS. DOT&E worked with the Office of the Undersecretary of Defense for Research and Engineering [OUSD (R&E)] to align those investments with the OUSD(R&E) Road to Dominance roadmaps. A portion of those investments targeted cyber software development and automated cybersecurity tools.

Faist: Agile concepts change how software is tested and push independent testing down into smaller groups. We need to better equip these teams with authoritative system-level emulators that allow continuous software testing without the physical hardware platforms. An extension of system emulation is being able to emulate the mission the fielded software will support. Thus, these teams also need an advanced mission engineering capability that provides a larger context of what a particular capability or software improvement brings to the fight and its impact on other systems on the battlefield. R&E is putting the foundation of infrastructure and expertise in place to apply these digital engineering and mission engineering needs throughout the DoD.

Another software challenge is that the quality of software is based on the developer's knowledge of the system, but we often lose the original developers because sustainment comes from a different pot of money than development, and the sustainers often end up being a different company with different people than the developers.

One of the big inefficiencies is a lack of good system engineering. DoD leaves systems engineering up to the developer, and it is often cut in an effort to save money. This cannot occur if we are going to improve the speed and relevance of our acquisition programs.

So, we asked you several questions related to how the T&E community is positioning the Department to achieve the three goals outlined in the NDS. What questions should we have asked you that we weren't clever enough to come up with ourselves?

Duma: Stepping into this future requires something we haven't talked about yet: people. Whether it's doing design differently or adopting systems engineering to produce digital engineering like Ed Kraft is working on, we need people with different skills than we have today.

Faist: The workforce health is very much in the red with recent retirements. We need to rebuild. There's nothing new with systems engineering today compared to pre-Internet days; it's just a people issue.

Will automated tools help the manpower problem by reducing manual testing, or will they complement manual testing?

Faist: It's an evolution. A technician tests something, then writes a script to automate the test and goes on to do something else. Automated testing is a force multiplier, but the human expert at the center is key.

The goal is engineering continuity through things like mission engineering and expansion of the role of the chief engineer. Change won't occur overnight. We are steering a very big ship.

Duma: This is a journey and a culture change. I use the mnemonic PEP – People, Equipment, Processes. They each need to be funded, and they each need to be evolved to adapt to the future. Our workforce is dedicated to the mission; we need to keep their skills up-to-date by expanding Defense Acquisition University courses with more advanced topics and improving other opportunities, such as ITEA training offerings.

Faist: We need to recapture our technological advantage in our ranges and facilities or we won't be able to compete with an advanced workforce and attract talented new people. It's not just about salaries, it's also about intangibles—like working on cutting edge technologies or not being on a contract that changes every five years. Working as a DoD civilian or on a DoD contract will always be among the most interesting and challenging jobs someone can have. We need the T&E community's help in getting that word out and attracting the talent we need for the future.

DAVE DUMA *is the Principal Deputy Director, Operational Test and Evaluation. He assumed this position in January 2002. Prior to returning to government service, he worked in private industry managing a variety of projects involving test and evaluation; requirements generation; command, control, communications, intelligence, surveillance, and reconnaissance; modeling and simulation; and software development. He served as Acting Director, Operational Test and Evaluation from February 2005 to July 2006, June 2009 to September 2009, and January 2017 to December 2017.*

Mr. Duma completed 30 years of Naval service, which included serving as the Acting Deputy Director for Conventional Systems in the office of Director, Operational Test and Evaluation and Director, Test and Evaluation Warfare Systems for the Chief of Naval Operations. His Naval career also included service as the Deputy Commander, Submarine Squadron 10 and Commanding Officer of the nuclear powered submarine USS Scamp (SSN 588).

Mr. Duma holds Masters of Science degrees in National Security and Strategic Studies and in Management. He holds a Bachelor of Science degree in Nuclear Engineering. He received the U.S. Presidential Executive Rank Award on two occasions; in 2008, the Meritorious Executive Award and in

2015, the Distinguished Executive Rank Award. He received two lifetime achievement awards for his work in defense test and evaluation; first in 2017, from the International Test and Evaluation Association and second in 2018, from the National Defense Industrial Association.

JAMES "JIM" FAIST *is the Director of Defense Research and Engineering for Advanced Capabilities, reporting directly to the Under Secretary of Defense Research and Engineering within the Office of the Secretary of Defense. Jim directs an organization whose mission is to recognize, explore, and accelerate the development and integration of new technology to maintain U.S. technological superiority. He is responsible for establishing a Department of Defense joint mission engineering capability, oversight of developmental testing and test facilities as well as demonstration and validation of technology prototype and rapid fielding activities. Jim serves as the mission area advisor for warfighter portfolios in hypersonics, space, autonomy, and networked command, control, and communications architectures. He also provides independent technical risk assessments of major acquisition programs.*

Mr. Faist has an extensive career in industry and government in national defense, including progressive responsibilities and experience in military operations, advanced technologies, system development, engineering leadership, and program management. He is a recognized expert in advanced sensors, weapons, and electronic warfare for space, air, and ground capabilities.

Mr. Faist was a chief engineer for the Northrup Grumman and Harris Corporations. He held senior executive positions at Schafer Corporation, Trident System Incorporated, and System Planning Corporation. Prior to his work in industry, he served in the United States Air Force as a Weapon Systems Officer and an Electronic Warfare Officer in the F-4D/E Phantom II fighter aircraft.

Mr. Faist earned a Bachelor of Science in Electrical Engineering for Virginia Military Institute in Lexington, VA, and a Masters of Science in Electrical Engineering from Cornell in Ithaca, NY, with emphasis on microwave and power systems. During his career he received numerous performance awards and honors from the U.S. Air Force, academia, and industry.

HEATHER WOJTON *earned her Ph.D. in Experimental Psychology in 2015 and is currently a Research Staff Member at the Institute for Defense Analyses. She leads a team of quantitative analysts that develop, apply, and disseminate statistical, psychological, and data science methodologies within the DoD and other national security organizations to facilitate data-driven decision-making.*

CHAD BIEBER *is a Research Staff Member at the Institute for Defense Analyses specializing in mobility aircraft, autonomy, and human factors. Previously, he flew very large airplanes for the US Air Force, then he taught little airplanes how to fly themselves at North Carolina State University. He is currently interested in how humans interact with complex and increasingly autonomous systems.*

RYAN NORMAN *has worked for the Test Resource Management Center (TRMC) since 2008, where he currently serves as the Deputy PM for the Joint Mission Environment Test Capability (JMETC), the Director for the Test and Training Enabling Architecture (TENA) Software Development Activity (SDA), and the TRMC lead for its Big Data Analytics and Knowledge Management (BDAKM) initiative.*

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