



Proven Warfighting Capabilities Delivered at the Speed of Need

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Overview & Strategic Drivers

The focus is on identifying the transformational changes that the T&E enterprise needs to implement to enable accurate characterization of the operational performance and limitations of the DOD to prevail in conflict and defend the homeland.

The following summarizes the desired end state and preliminary actions to motivate a call for action across government, industry, and academia to define the right measures of performance and accelerate the proposed transformation.

We have identified seven disruptors, there may be more, that are driving us to rethink the way we do T&E.

- 1 | Engineering of Software and Software Reliant Systems
- 2 | Artificial Intelligence and Machine Learning
- 3 | Joint All Domain Operations
- 4 | Data
- 5 | Speed to Field
- 6 | Culture
- 7 | Talent Management

1. Engineering of Software and Software Reliant Systems

Modern software development techniques introduce one of the greatest departures from traditional T&E approaches – a need for a truly integrated, iterative, yet still independent T&E, from code conception to software deployment on our weapon systems.



CHALLENGE

- Traditional operational T&E **concepts that focus on one large test** in support of a full-rate production decision **are not suitable** for modern software practices of rapidly deploying capability upgrades.
- Instead, the adequacy of software T&E design, execution, and reporting depends on their **integration into the software pipeline and systems engineering process**, while also ensuring continuous **user engagement** and **operationally representative conditions**.



FACTORS

- Contractors' **supply chain risk management, program protection, cloud services, software factories, and data rights** represent critical factors in the evaluation of software operational effectiveness, suitability, survivability, and lethality (as applicable).
- The execution of such T&E within **existing organizational structures, laws, and policies** presents a challenge.



OUTLOOK

- It is not yet, for example, fully defined how government T&E could **interface with software development teams** while still **maintaining their independence**. It is also not clear how to **invoke flexibility** to keep pace with the software development cadence while still meeting all documentation requirements.

As we consider these challenges for software we might also consider them for hardware-intensive systems, because there may be some lessons learned here for all of T&E.

2. Artificial Intelligence and Machine Learning

Related to engineering of software and software-reliant systems, artificial intelligence (AI) and machine learning (ML) are transformational technologies that introduce yet another layer of complexity to T&E.



CHALLENGE

- Rigorous, defensible testing of AI-enabled systems **requires additional research to evaluate AI algorithms and ML models**, to **ensure AI assurance**, to certify that **AI algorithms operate as intended** and are **free of vulnerabilities** either from faulty design or from maliciously inserted data or code.



FACTORS

- T&E also needs to consider the uniquely contextual operational and responsible **performance of AI/ML capabilities**, especially as they learn and change during real operational use.



OUTLOOK

- **Where does AI T&E begin and where does it end?** Or should it end at all?
- What **tools and processes** do we need to put in place to enable **continuous evaluation of AI-enabled systems** as they get exposed to new and different operational environments?

Some form of T&E during operations and sustainment might be our new reality and we may have to use AI itself and other digital tools to enable such T&E and the related scaling challenges.

3. Joint All Domain Operations

Joint all domain operations bring into question the entire concept of testing one system at a time, as has been done historically.



CHALLENGE

- **Testing the mission threads that make up the system-of-systems environment**, to include the entire potential attack surface and the persistence we expect from our adversaries.



FACTORS

- Will require **tools and infrastructure** that facilitate continuous and automated T&E.
- Will require **physical and virtual infrastructure** that can **represent the operating environment** that is changing in both space and time.



OUTLOOK

- **Training and large force exercises** to leverage the various test and training events and corresponding infrastructure.
- **Range/training capability requirements, mission thread requirements, a joint T&E organization(s)** to plan and execute such events and the associated T&E concepts and cost.

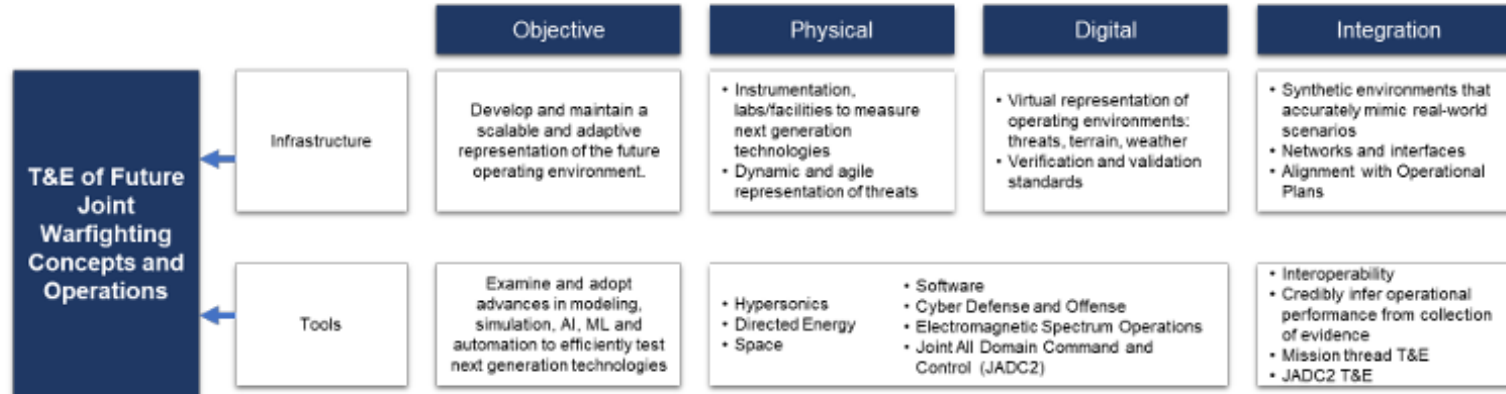


Figure 1. Crude summary of the physical and virtual infrastructure and tools needed to support T&E of joint warfighting concepts and operations.

4. Data

The effectiveness of joint all domain operations will hinge on the ability of relevant systems to deliver information advantage at the speed of relevance: the ability to ingest, sense, analyze, predict, decide, act, and secure data across the entire Joint Force, at every echelon, from the strategic level to the tactical edge, at machine speeds.



CHALLENGE

- Will require innovative T&E **data management tools to measure and evaluate data-oriented operational performance**, especially as data and elements of the kill webs change over time.



FACTORS

- The collection, analysis, and high-level aggregation of **test data** must be **networked and automated**.
- **Infrastructure must be integrated with a unified data-driven, all-domain modeling and simulation (M&S)** to complement live testing in conditions not possible in live tests due to environmental, fiscal, safety, classification, and ethical constraints.



OUTLOOK

- Need **raw streaming data** from the platform, **onboard data reduction**, and **distributed raw binary data stores**.
- Need data post-processing to machine-readable formats; integration into data-backed M&S; “online” system performance analyses using an open, general-purpose automated data analysis environment; and ad hoc “offline” manual, analyst-performed experimentation and development.
- **Leverage the DOD’s Advana1 platform** for big data-aggregated advanced analytics using a data mart² composed of high-level system performance analysis artifacts.

5. Speed to Field

Speed to field is another challenge for the T&E community brought to us by an increasingly capable adversary with access to new science and technologies.



CHALLENGE

- **Accelerating warfighting capability** to the field while **not compromising quality** and while also **confronting the complexity of the technologies** themselves requires innovative, if not revolutionary, T&E approaches.
- The DOD's Digital Engineering Strategy states that *current acquisition processes and engineering methods hinder meeting the demands of exponential technology growth, complexity, and access to information.*



FACTORS

- **Digital engineering** offers an opportunity to enable the acquisition and T&E forces to automate and accelerate workflows and processes.
- **Adaptive test planning and execution** also offer opportunities to enable faster and more efficient acquisition: the test adequacy for any phase of test is dependent on the outcome of prior testing.



OUTLOOK

- These dependencies in time among prior observed test results, test assets, and tested capabilities/conditions/limitations suggest the **creation of a test design** that is both **sequential and adaptive** to support optimal but adequate T&E in a way that most efficiently **leverages data collected** across the test life cycle.

6. Culture

There are several factors that affect the T&E culture that may have to be reconsidered to enable the transformation of T&E processes and outputs.



CHALLENGE

- **Communication** is key to success, no matter the situation.
- The **value** of T&E can be difficult to appreciate but not if it is characterized as an approach to **quantify risk to the program and the warfighter**.
- **Change** can be difficult to accept and even more difficult to implement, but continuous change will be the T&E reality as we transition into a digital ecosystem.



FACTORS

- **Disparate test communities**, sometimes spread across different corners of the country, **different appreciations for test** as compared to M&S, **different priorities**, and misunderstandings can get in a way of progress, even though all acquisition and T&E stakeholders have the same objective – that is to **support the warfighter**.



OUTLOOK

- **Common data and tool repositories, digital engineering, secured and available networks, and infrastructure** may improve communication within T&E working-level integrated product and test teams and within the T&E enterprise to identify, prioritize, and track T&E capability requirements.
- Programs would benefit **from including T&E stakeholders in the development of requirements** to evaluate their scope and testability. Similarly, acquisition contracts should also be informed by T&E to confirm access to needed data, artifacts, tools, support to government T&E, and similar.

7. Talent Management

Emerging technologies and digital transformation concepts will require unique skills that the existing workforce may not have.



CHALLENGE

- Some fields such as **software engineering, AI, and cyber science** are changing rapidly, requiring continuous training and professional development.



FACTORS

- The T&E community has been absorbing responsibilities to keep pace with emerging threats, leaving **minimal to no room for training, learning, mentorships**, or the like. In addition, high-demand skillsets are also sought by the commercial sector, making it even more challenging for the government to acquire and retain the right T&E workforce.



OUTLOOK






- The T&E community is left with the challenge to craft a new approach to recruitment, training, education, and long-term management of the talent pipeline.

Strategy and Implementation Plan

To respond to these disruptors, the Director, Operational Test and Evaluation, HON Nickolas Guertin, challenged us to work with him on a strategy that will **help transform T&E and enable the delivery of the world’s most capable warfighting capability**. Under his leadership, we defined the desired end state as five strategic pillars.

Requirements, intelligence, and the acquisition pathways are the foundation of the T&E process. These T&E activities will realize the goals of the five strategic pillars that will in turn inform T&E policy and guidance with the potential to inform operational and system requirements, system development, and acquisition contracts.

Table 1. Strategic Pillars of T&E Transformation and Capability Delivery

Pillars	Key Actions	Desired End State
 <p>Test the Way We Fight</p>	Architect T&E around validated mission threads and demonstrate the operational performance of the Joint Force in multi-domain operations	<ul style="list-style-type: none"> Accurate representation of the Joint, multi-domain operating environment in test Adequate evaluation of Joint warfighting capabilities and mission threads (kill webs, system-of-systems performance)
 <p>Accelerate the Delivery of Weapons That Work</p>	Embrace digital technologies to deliver high-quality systems at more dynamic rates	<ul style="list-style-type: none"> Discoverable, accessible, and secure data repositories Near-real-time test data analysis and assessment Established tools and processes that optimize integrated T&E Digital documentation and tracking of T&E strategies and plans
 <p>Improve the Survivability of the DoD in a Contested Environment</p>	Identify, assess, and act on cyber, EMS, space, and other risks to the DoD mission – at scale and speed	<ul style="list-style-type: none"> Minimized mission-critical vulnerabilities in a contested environment Timely tracking and response to mission-critical vulnerabilities as systems and threats evolve
 <p>Pioneer the T&E of Weapon Systems Built to Change Over Time</p>	Implement fluid and iterative T&E across the entire system life cycle to help assure continued combat credibility as the system evolves to meet warfighter needs	<ul style="list-style-type: none"> Standardized and increased use of credible digital twins in T&E Adequate assessment of operational and ethical performance of AI-enabled systems Effective tracking of any degradation of operational performance of DoD systems in theater
 <p>Foster an Agile and Enduring T&E Enterprise Workforce</p>	Centralize and leverage efforts to access, curate, and engage T&E talent to quicken the pace of innovation across the T&E enterprise	<ul style="list-style-type: none"> Highly skilled T&E workforce prepared to meet the toughest challenges Effective continuous learning program and a robust recruitment/retention plan Agile and innovative workforce operating model

Conclusion & Questions

The DOD faces a shifting threat landscape and the need to swiftly leverage advanced technologies to increase the lethality, suitability, resiliency, survivability, agility, and responsiveness of our future Joint Force. To continue to deliver credible warfighting capability at the speed of need, the acquisition and T&E enterprise must rethink traditional approaches. We must respond with agility, efficiency, and effectiveness to adequately account for the technology disruptors as we face an inflection point in the scope, scalability, and capabilities of our infrastructure, tools, processes, and workforce.

Any Questions?

The T&E enterprise of the future must be agile, motivated by mission thread approaches, joint warfighting concepts, and the power of digital tools and technologies. It must be strengthened by the effects of these changes on our ability to support the warfighter. It must be empowered by continuous learning and supported by unbound access to state-of-the-art skills and technologies to be better positioned to stay ahead of the adversary and continue to advocate for the warfighter and its mission as defined by the National Defense Strategy 2022.