

Test Range of the Future - Implications on Test Design and Instrumentation

The National Academies of SCIENCES
ENGINEERING
MEDICINE

Necessary DoD Range Capabilities to Ensure Operational Superiority of U.S. Defense Systems



NECESSARY DOD RANGE CAPABILITIES TO ENSURE OPERATIONAL SUPERIORITY OF U.S. DEFENSE SYSTEMS

Phase 1 Study Objective - Unclassified

Assess **the physical and technical suitability of DoD's ranges, infrastructures, and tools** used for test and evaluation of military systems' **operational effectiveness, suitability, survivability, and lethality** across all domains in the 2025-2035 timeframe

Key Findings - Major Themes

- A. Future combat will demand **connected kill chains** in a **joint all-domain operations** (JADO) environment;
- B. **Digital technologies** are dramatically reshaping the nature, practice, and infrastructure of test; and
- C. **Speed-to-field** is today's measure of operational relevance.

Aggressive action is required by the DoD otherwise the test ranges will be physically and technically inadequate to address the future fight

Key Challenges Raised

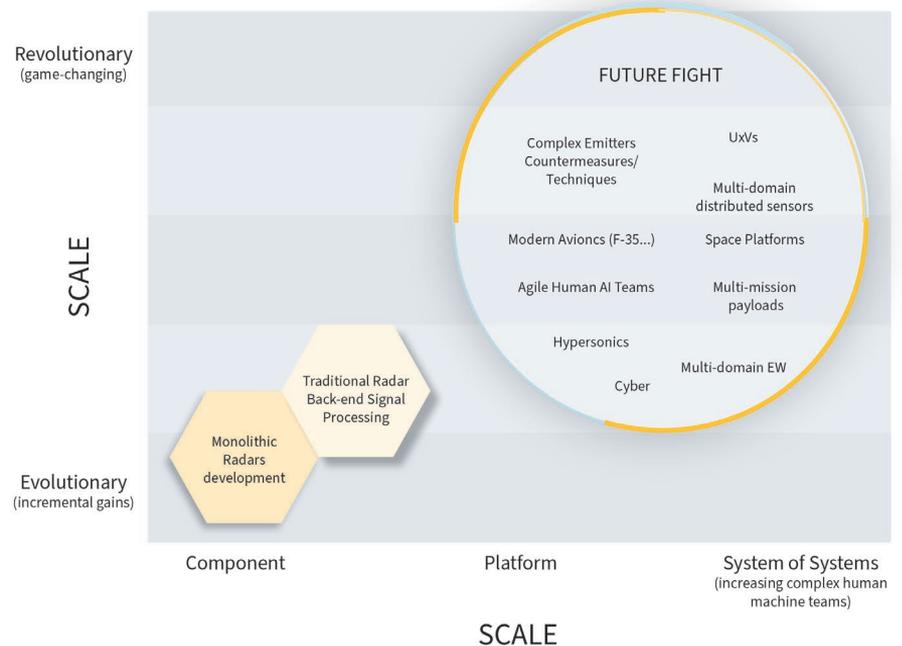
- Developing new testing capabilities
- Limited space and encroachment
- Integration
- Modeling & simulation
- Measurement and data
- Digital infrastructure
- Cybersecurity
- Workforce
- Financial challenges

Recommendation Themes

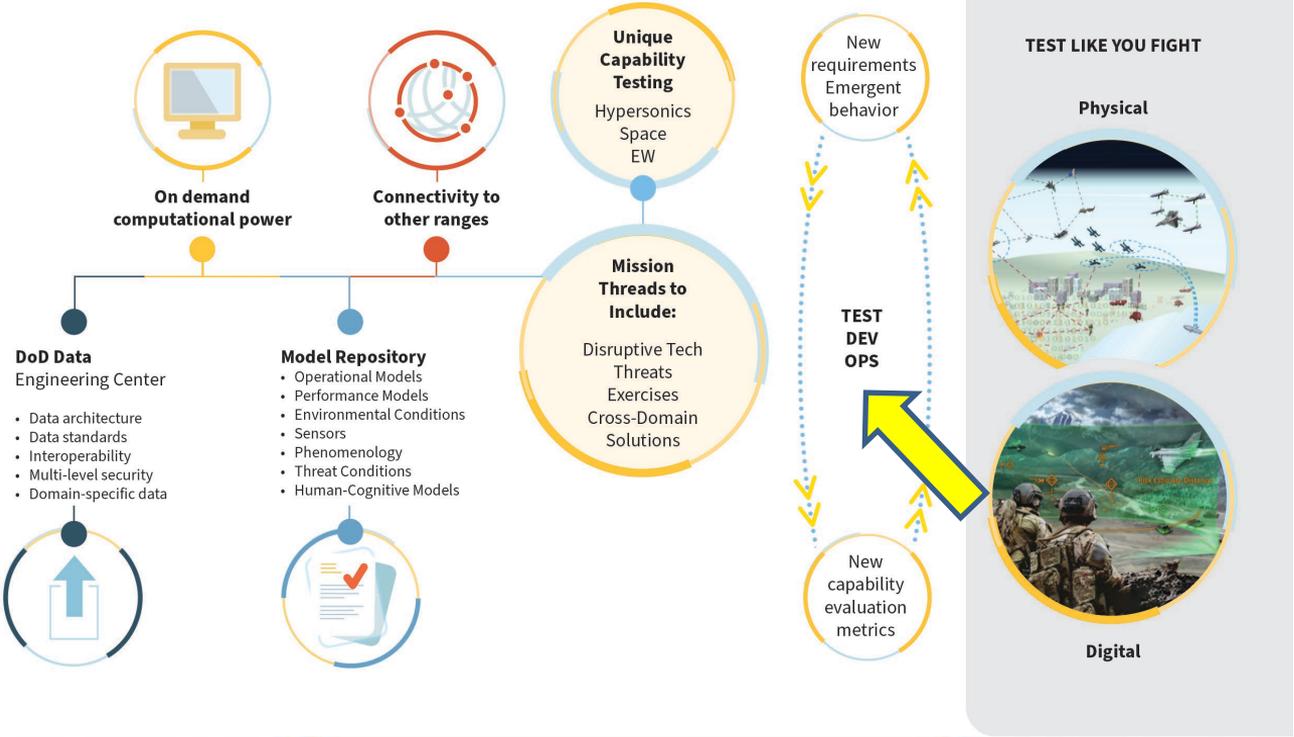
1. Develop the “range of the future” to **test complete kill chains in JADO environments.**
2. Restructure the range capability requirements process for **continuous modernization and sustainment.**
3. Bootstrap a **new range operating system for ubiquitous M&S** throughout the weapon system development and test life-cycle.
4. Create the **“TestDevOps” digital infrastructure** for future operational test and seamless range enterprise interoperability.
5. Reinvent the range enterprise **funding model for responsiveness, effectiveness, and flexibility.**

The Envisioned Future of Operational T&E Addresses:

- Novel weapons and domains
- Multi-domain operations and kill chains
- Modeling & simulation
- Data sharing, repositories, and accessibility
- Funding and acquisition
- Encroachment Mitigation



Notional Concept of the Test Range of the Future



Test Complete Kill Chains in JADO Environments

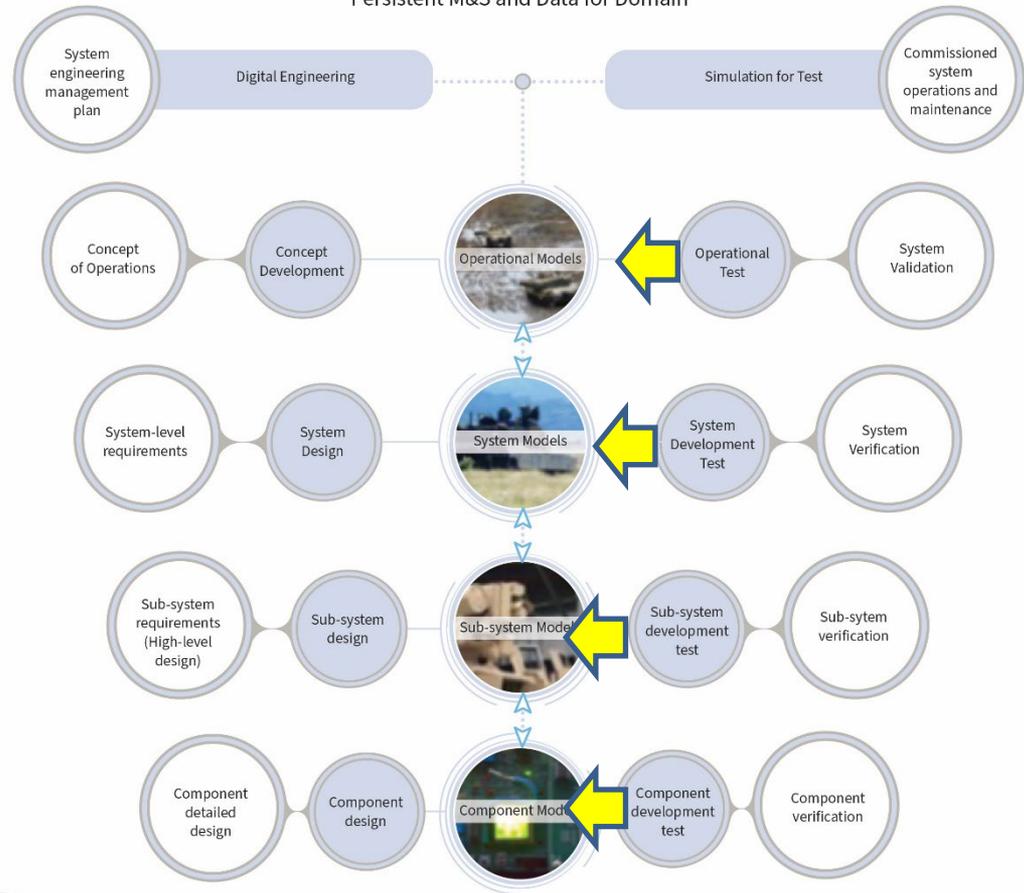
Recommendation 3-1: To enable a range of the future that is capable of testing **kill chains and multi-domain operations (MDOs)** that can integrate effects across National Defense Strategy **modernization areas**, the Secretary of Defense should address the need to enable the DoD ranges to **provide regular venues to “test as we fight”** for acquisition and prototyping programs in a joint multi-domain battlespace of integrated systems.



A New Paradigm for Integrating Testing with Simulation

M&S IN SYSTEM LIFECYCLE EMERGING PRACTICE

Persistent M&S and Data for Domain



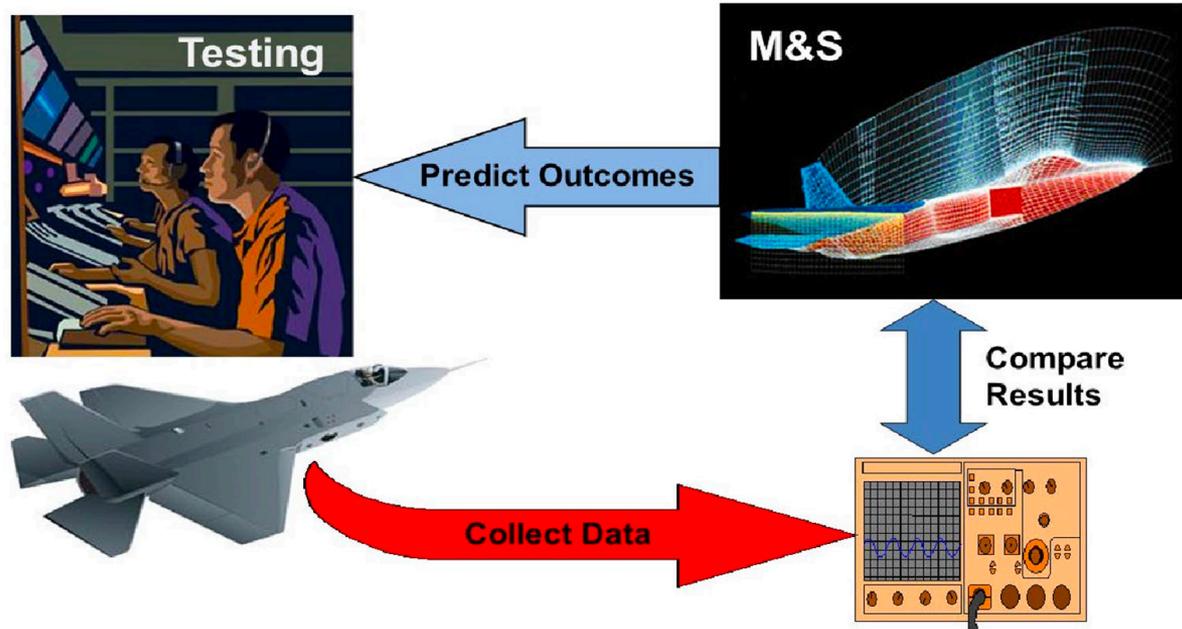
Implementation hardware and software (Coding and Test)

Ubiquitous M&S / TestDevOps Digital Infrastructure

A DoD joint program office should:

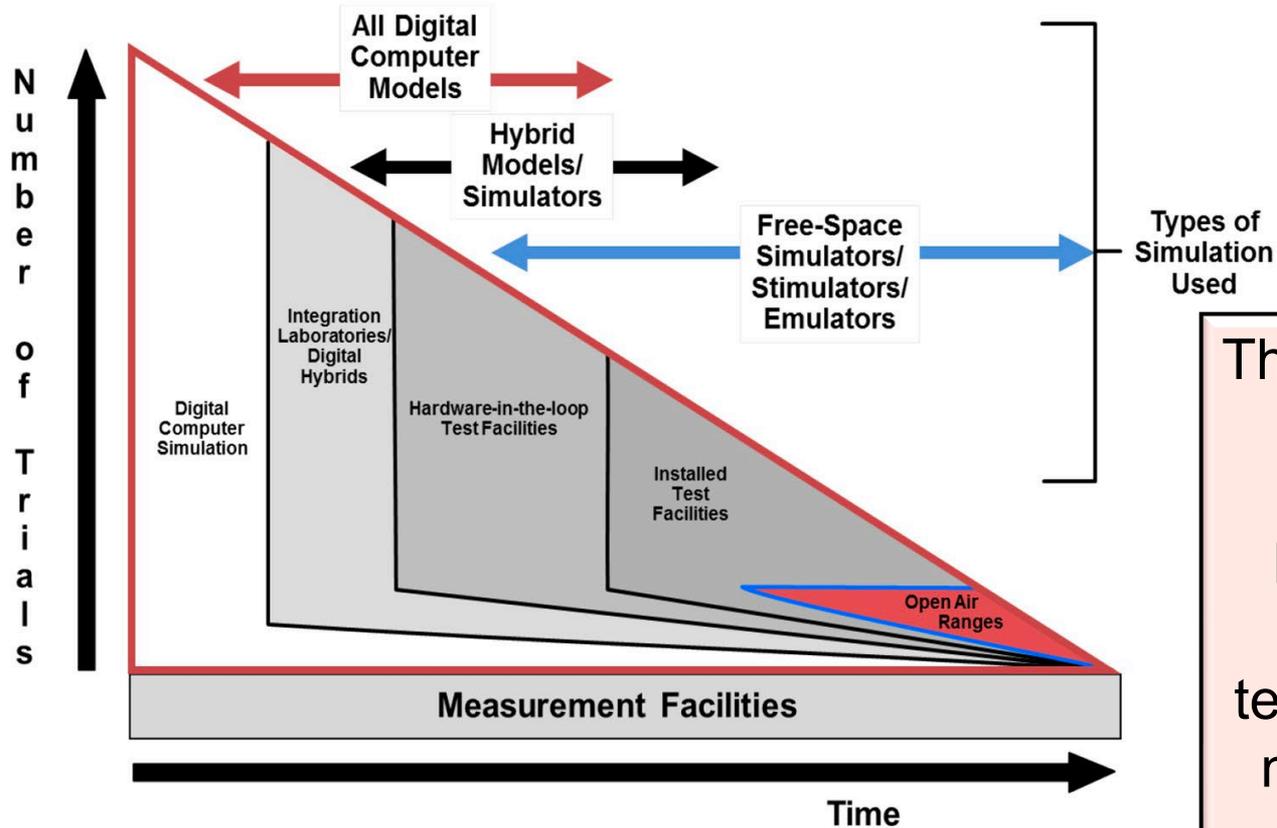
- Establish a shared, accessible, and secure M&S and data ecosystem. Integrated live test and M&S should be planned from early concept development to support the system life cycle. (Recommendation 4-1)
- Adopt and promulgate approaches for standardization, architectural design, and security efforts to address data interoperability, sharing, and transmission challenges posed by the complexity of next generation systems.
- Determine how to develop and maintain a protected data, model, and analysis repository for testing. Increase the interconnectivity of test ranges, and ensure the development of data protocols for the real-time transfer of data at multiple classification levels. (Recommendation 4-2)

Time to Change The Image For T&E



This view does not fully exploit the power of modern M&S

Time to Change The Image For T&E



This does not fully capture the relationships between M&S and physical testing and cyclic nature of those relationships

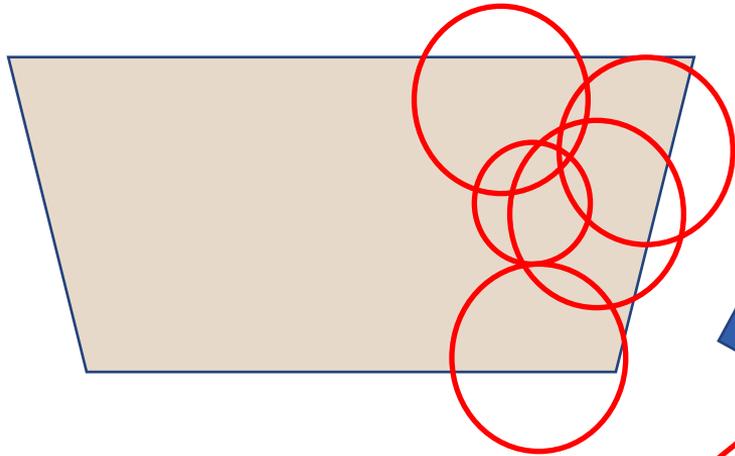
Virtual Physical?



Virtual **and** Physical

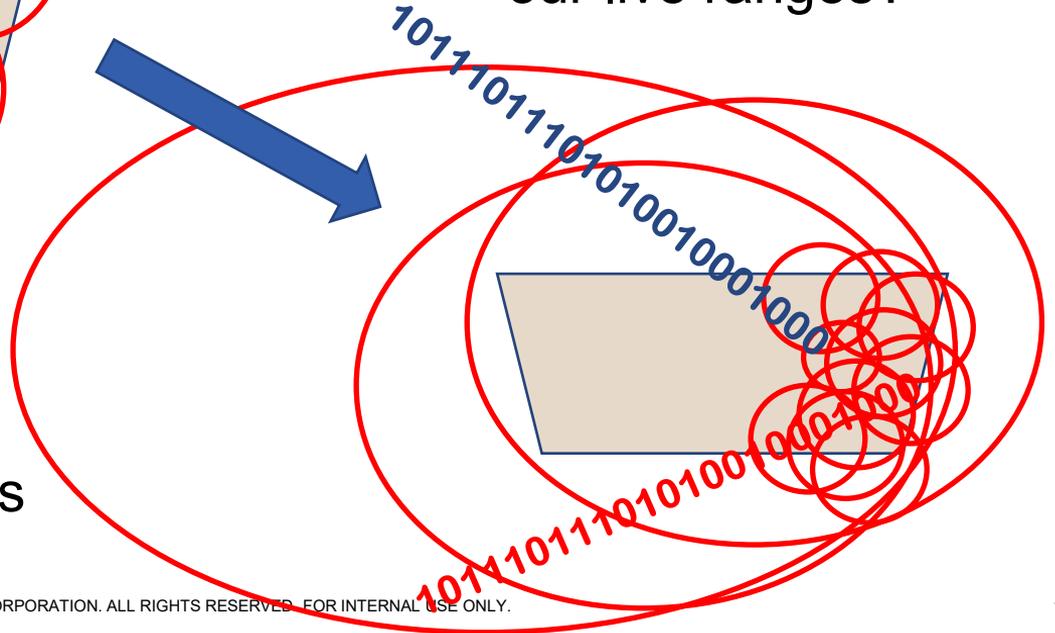
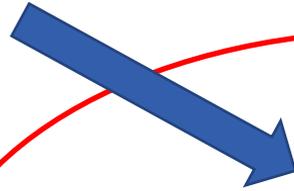
To use M&S to greatest effect, it will be necessary to integrate testing and simulation more closely than is currently the case.

Representing the Operational Environment

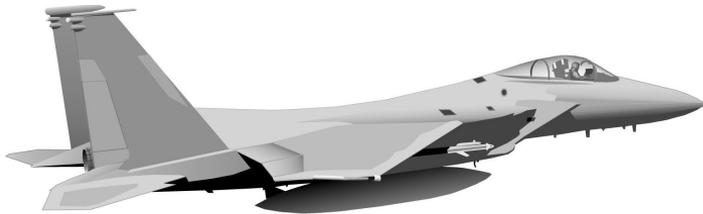


Can we physically represent the Operational conditions in our live ranges?

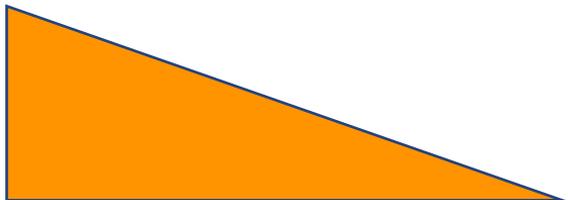
Distances
Densities
Reserve Modes
Non-Kinetic Combined Effects



The Changing System Under Test



**5000.2 Clear Production
representative Milestone**

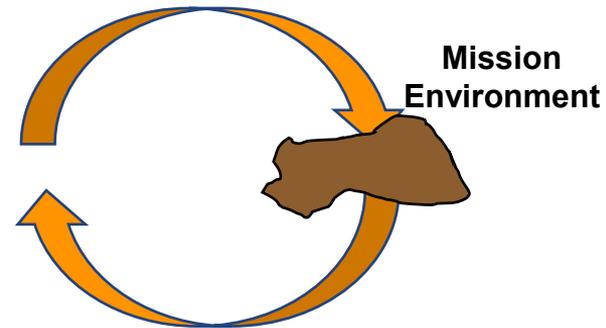


How should test and
evaluation SMEs inform
program to build data
capture into the system?

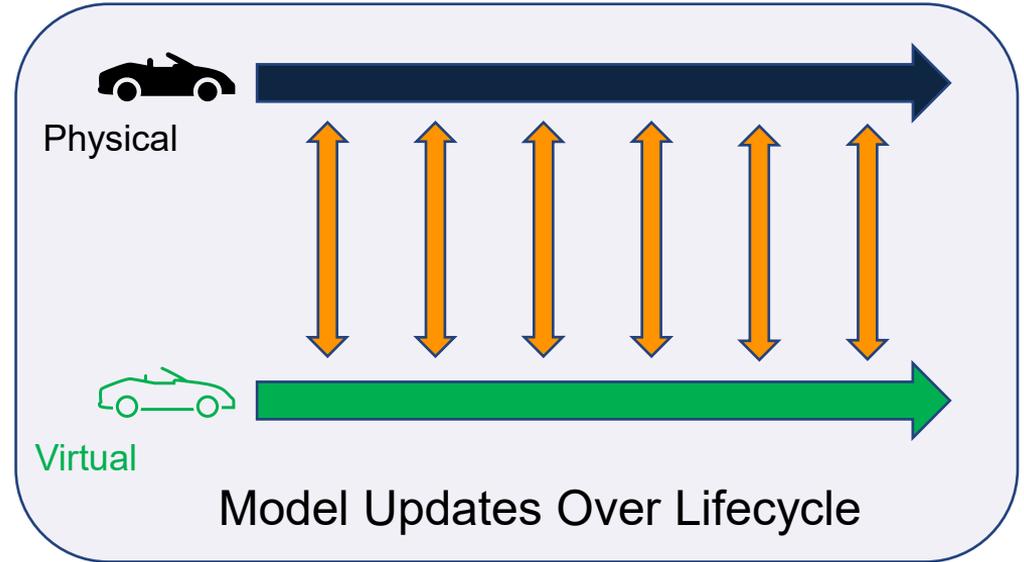
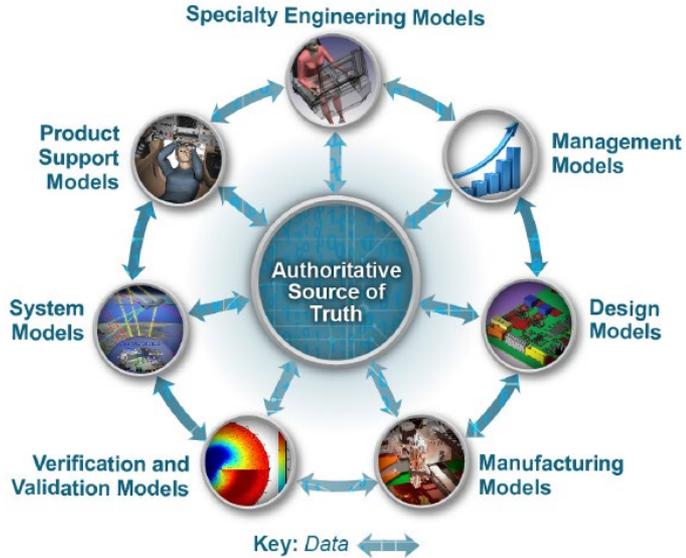
What data is collected and
presented to “train” a
machine learning system?



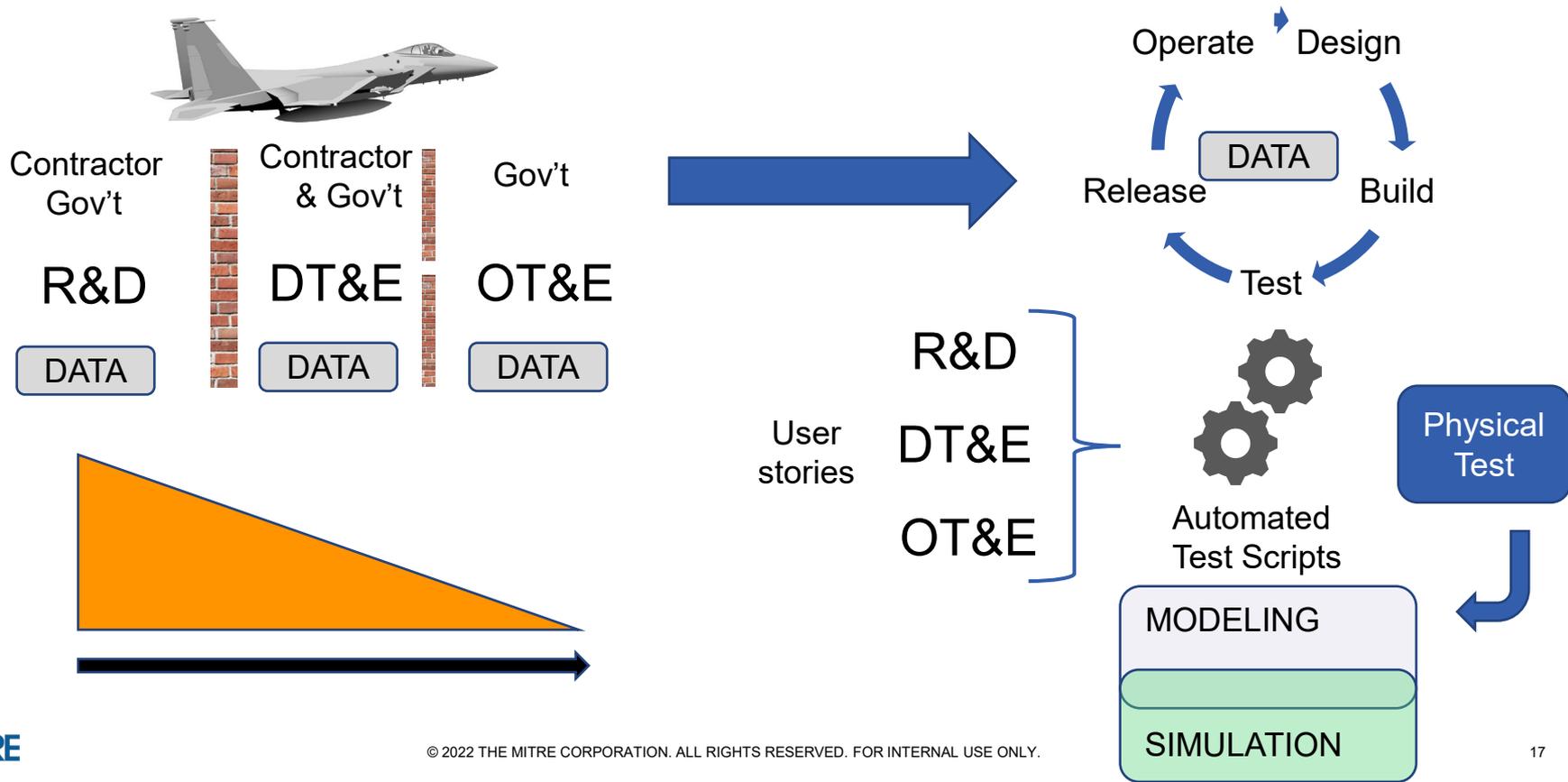
**5000.87 Rapid
Software Iteration**



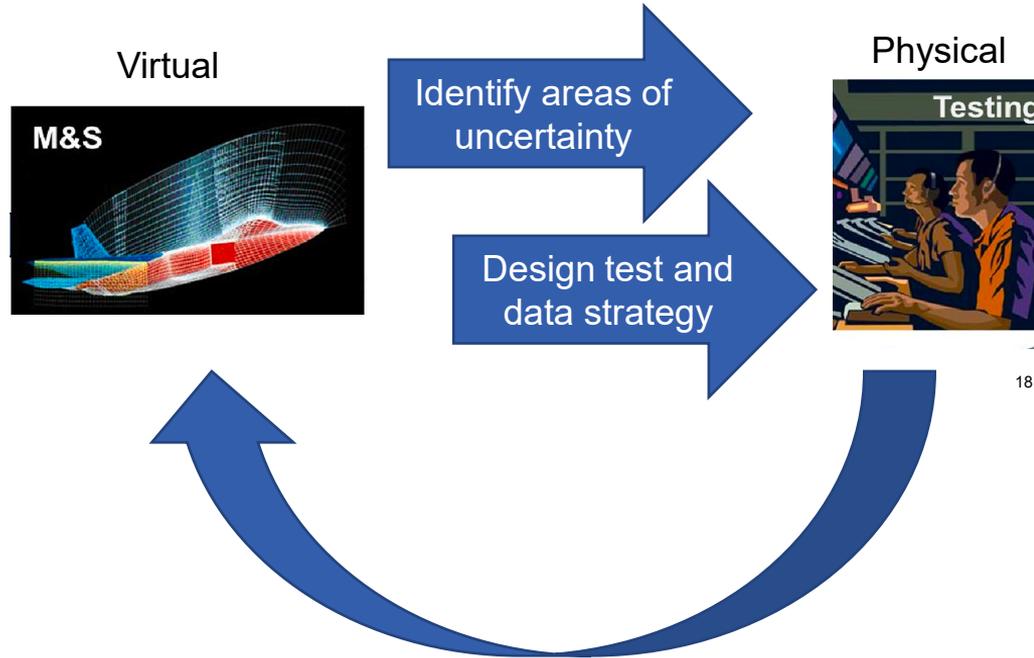
The Digital Thread



Continuous Test and Evaluation

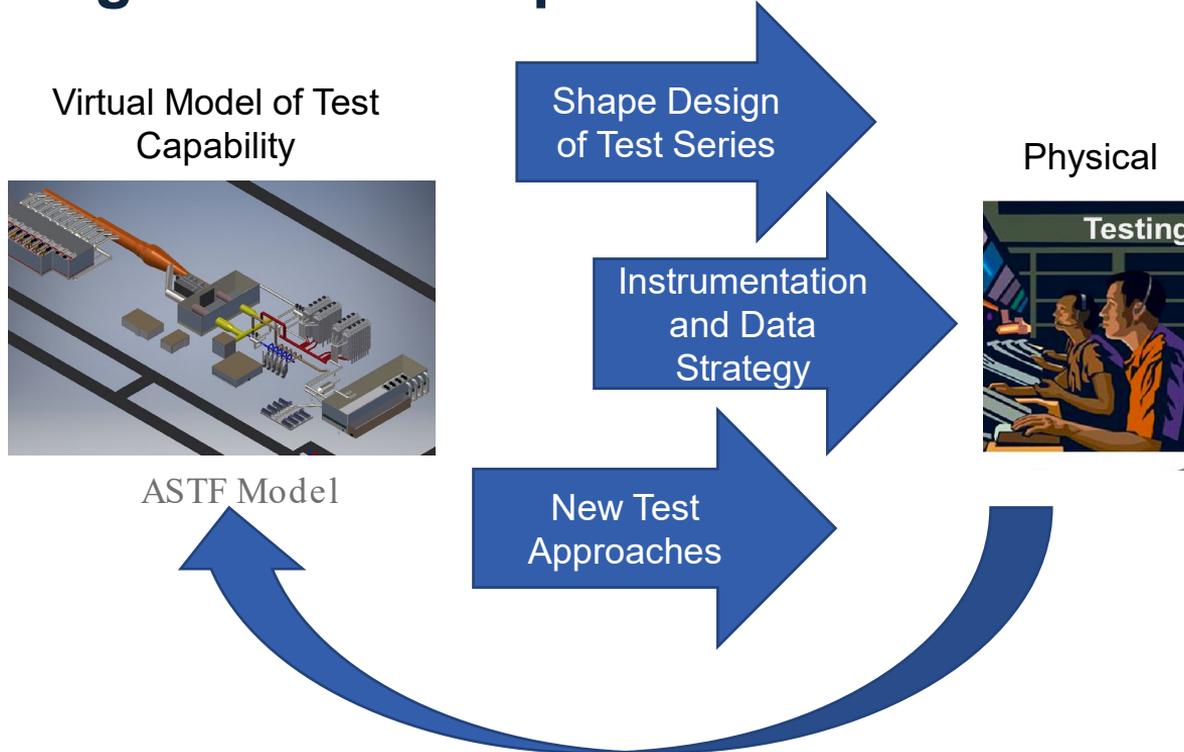


Design and Methodology to Reduce Model Uncertainty



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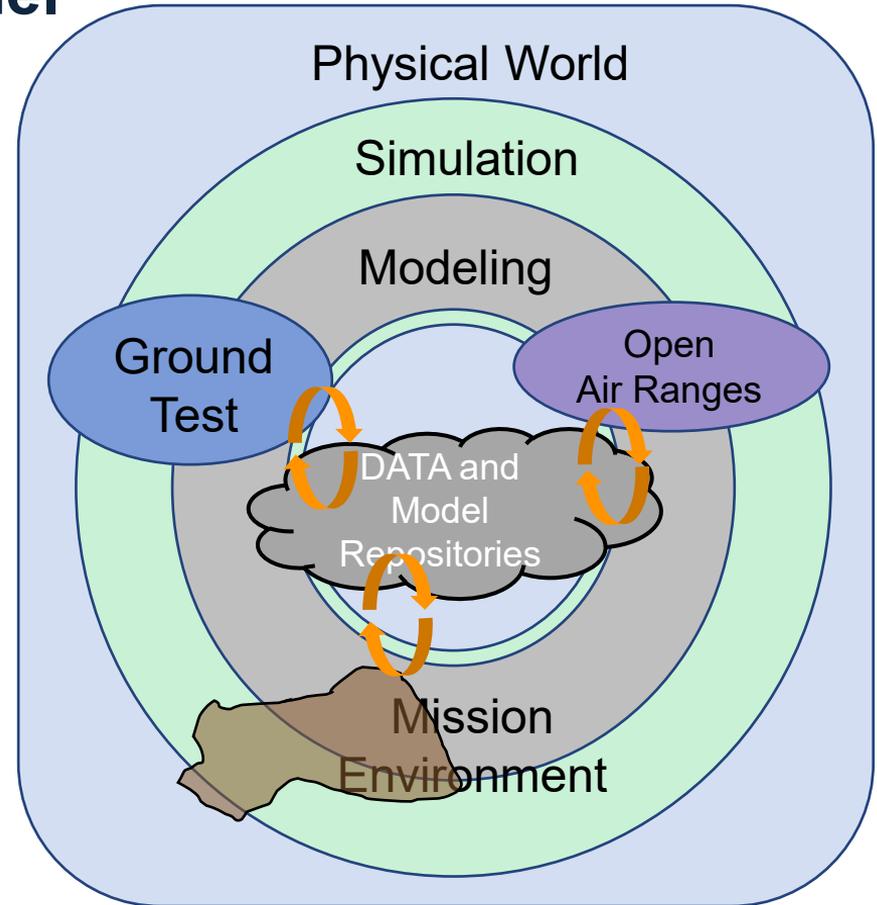
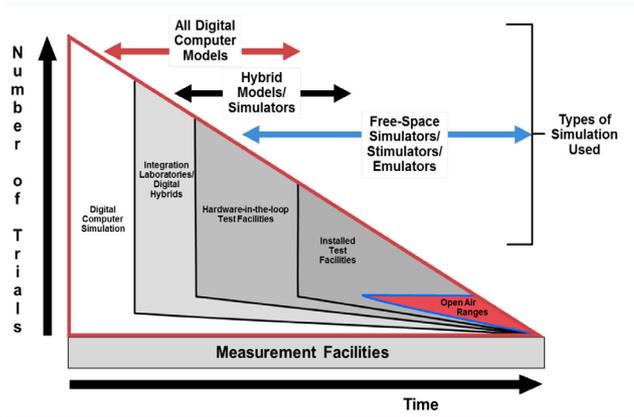
Use of Digital Twin to Optimize Test Methodology



ASTF = Aeropropulsion Systems Test Facility

<https://www.arnold.af.mil/News/Article-Display/Article/1540429/aedc-innovation-grant-allows-for-completion-of-3-d-astf-model/>

Evolving from the Wedge Model



Phase 2 Study - Classified

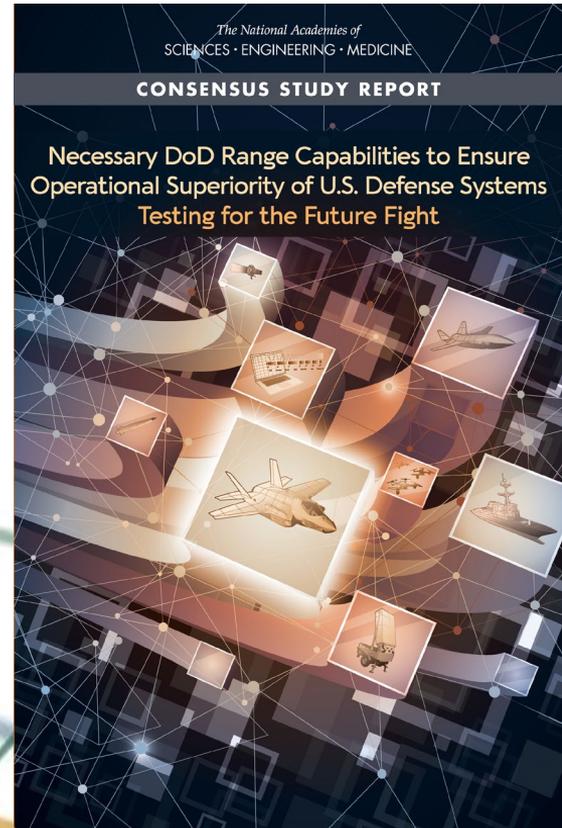
Objective is to assess:

- Threat and threat countermeasures replication
- Capacity for advanced weapons and new technologies
- Modeling and simulation range of the future
- Topics that could not be assessed in Phase 1

Study kicked off 11 August 2021

The PDF of the report is
available to download at

[NAP.edu/26181](https://www.nap.edu/26181)



Backup

Joint Program Office

A new organizational construct embodied in a joint program office is recommended to manage the framework for testing kill chains across systems and technologies. This office could:

- Lead an effort across Joint Staff elements to **define representative multi-domain use cases and to prioritize MDO and kill chain tests** and associated test resources;
- Provide inputs to prototypes, programs, and services on needed future developments based on MDO test results (Continuous “TestDevOps”)
- Provide and advocate for **funding to support execution of multi-domain test events and sustainment of capabilities** needed to execute those events;
- Establish a **shared, accessible, and secure modeling and simulation (M&S) and data ecosystem** to drive integrated development and testing across the life cycles of multiple supporting programs.

Ubiquitous Modeling & Simulation

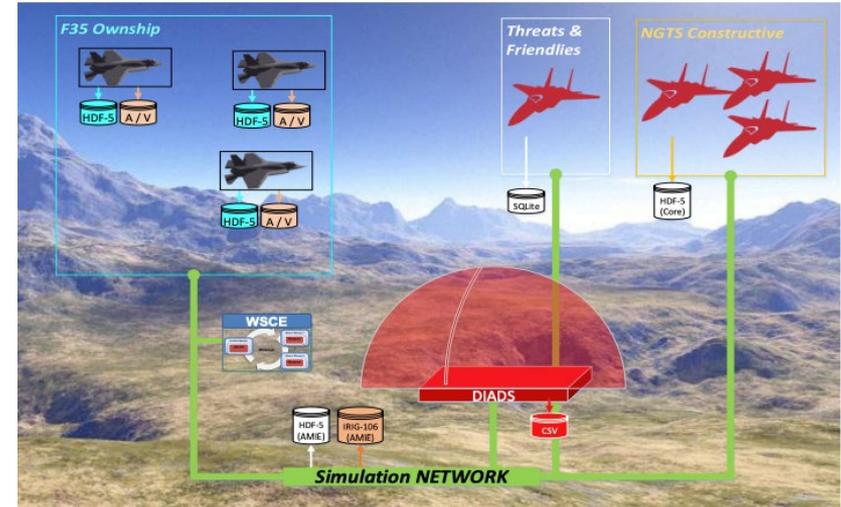
Example: The Joint Simulation Environment

The JSE is a high-fidelity simulation environment for operational testing.

It addresses a recognized need, in the JSF and other programs, for test operations unsuitable for open air ranges.

Future programs should not have to build their own JSE late in the program lifecycle.

Need persistent M&S environment suitable for continuous “TestDevOps”



Source: NAVAIR Public Release 2017-1012

Enable Continuous Modernization and Sustainment

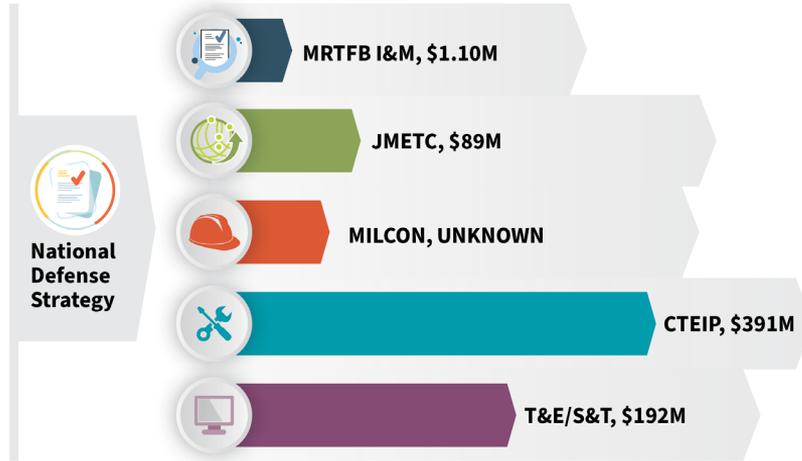
T&E infrastructure development is often state-of-the art with innovative capabilities that may not align with expenditure guidelines.

Recommendation 5-2: The Office of the Secretary of Defense (OSD) should either **allow an exemption or set shallower expenditure benchmarks for the first 2 years of test modernization programs.** This will reflect realistic expense curves for the technologies and projects needed to test next generation programs and complex integration.

Conclusion 5-1: **New mechanisms and funding limits for applying minor military construction** are necessary for responsive T&E activities

The COLOR\$ of Money for Range Modernization

FY 2020 RANGE MODERNIZATION INVESTMENTS



Conclusion 5-2: There exists a need for the Department of Defense to **pilot new process and authorities for funding ranges and infrastructure** to make them simpler, more responsive, and more effective.

- Create a **working capital fund** to cover operational, recapitalization, modernization, and sustainment costs of ranges;
- Offer **flexibility in funding authorities**;
- **Simplify resource allocation, financial management, and acquisition processes** that impede rapid and efficient funding of ranges and infrastructure;
- Ensure **appropriate cost control through a rate board**.