T&E in the Digital Engineering (DE) Campaign

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24 July 2020

Approved for public release; distribution is unlimited. 412TW-PA-20444

BLUF

- **Take the Red Pill**
  - **Dr. Will Roper, Assistant Secretary of the Air Force for Acquisition, Technology and Logistics**
  - **"True successor to stealth: big paradigm shift for military tech dominance"**
  - **Trinity of Digital Engineering and Management, Agile Software and Open Architecture**
  - **Rather than just building better systems, it builds systems better**
    - **Opens doors to faster design, seamless assembly, and easier upgrades**

- **T&E plays a key role in this process**
  - **AFTC has representatives on all Digital Campaign LOEs**
  - **AFTC already leverages digital processes to collect and analyze tremendous amounts of technical data that can inform digital processes**
    - **We need a solid IT infrastructure to tie it all together**

https://www.af.mil/Portals/1/documents/2020SAF/ThereIsNoSpoon.pdf?ver=PzCkeYB_IMIbJCRSyqEMPA%3d%3d&timestamp=1600698036535

OUTLINE

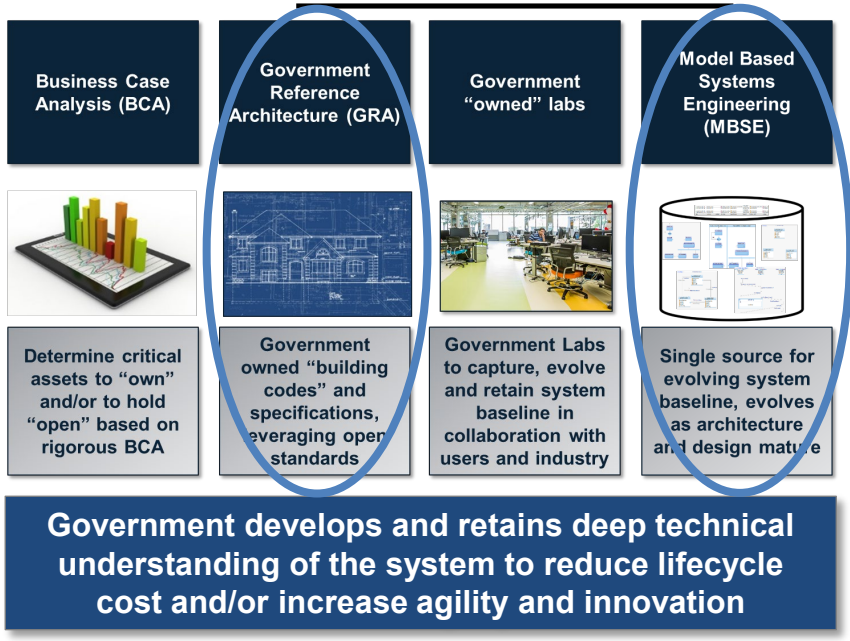
- AF Digital Engineering Campaign
- AFTC current use of Digital Engineering
- Vision: T&E in Digital Engineering
- AFTC support to the AFMC Digital Campaign
- Way forward

AF DE CAMPAIGN

Focus of AF DE Campaign

- DE Campaign is the evolution of "Owning the Technical Baseline" (OTB) initiated by Dr. Bill LaPlante in 2014
- Perceived OTB Benefits
  - Government retains control of key interfaces, designs and data
  - Government understands what it's buying
  - Enables competition which:
    - Drives down cost
    - Fosters innovation
    - Fleshes out risks earlier
  - Government understanding of cyber threat surface
  - Enables speed and agility, particularly in modifications later in life cycle

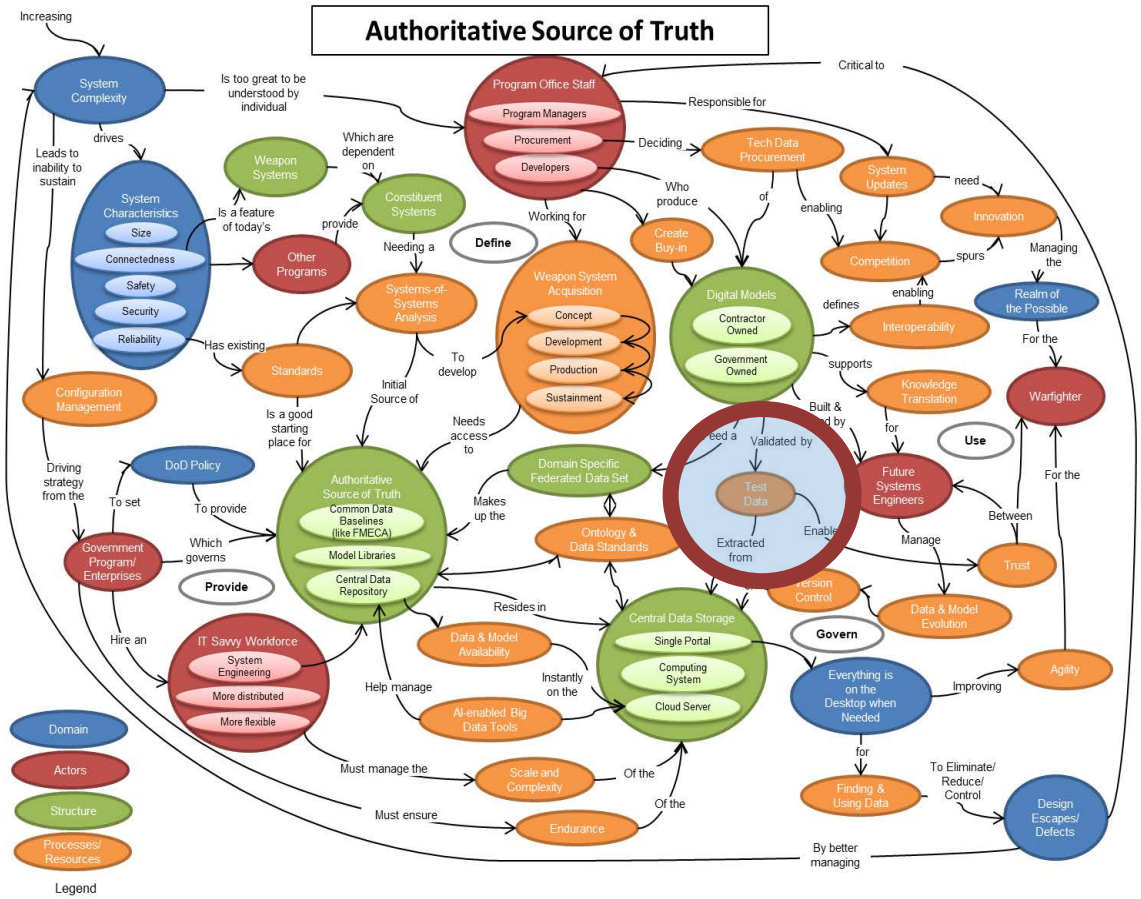
Four OTB Enablers



DE LOE 2 – is highly focused on GRA and MBSE
T&E Specific LOE should focus on the Government "owned" Labs and Test Capabilities

Authoritative Source of Truth – Digital Engineering

- **Big Rocks from AF Perspective**
  - Technical Data Package + (TDP+)
  - MS&A Capability
  - Integrated Digital Environment
  - Workforce Development
  - Contract Language
  - Lifecycle Strategies
  - Prototyping and Experimentation
  - Authoritative Source of Truth (ASoT)
  - DevSecOps
  - IT Infrastructure
  - Collaboration with Industry



- **T&E is not considered a big rock**

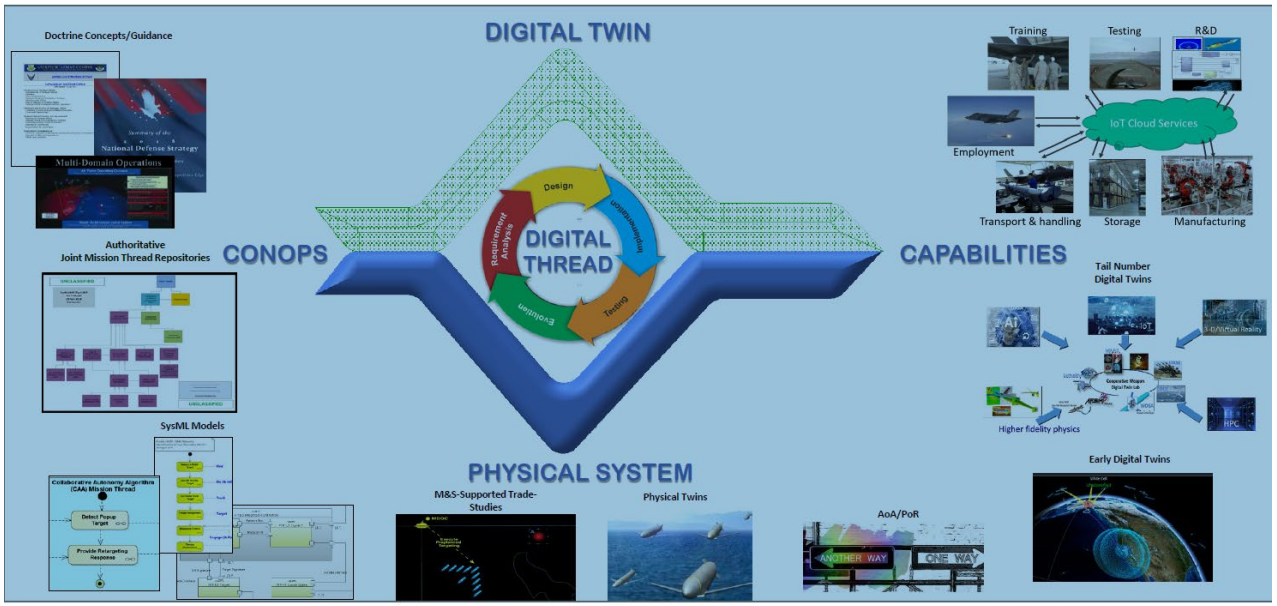
AF Pathfinder Programs

- **Pathfinders**
  - **A10**
  - **B52**
  - **F-15EX**
  - **Ground Based Strategic Deterrent (GBSD)**
  - **R-EGI**
  - **Skyborg**
  - **T-7A**
  - **WDE**

- **AFRL Weapons Development Environment (WDE)**
  - **Conceptual development using DE principles to accelerate fielding of a weapon**

WDE Concept using integrated Physical System and Digital Twin is key

- **Provides "hooks" for integrating T&E into Digital Engineering**



Digital Engineering is an integrated approach that uses authoritative sources of **system data and models** as a continuum across disciplines to support lifecycle activities from concept through disposal

AF DE Campaign – Lines of Effort

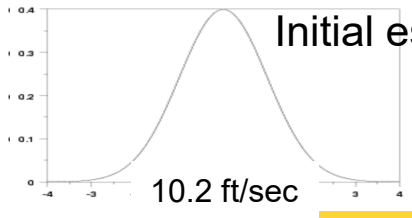
- LOE O – Integrated Environment - IT Infrastructure
  - GOAL: Provide overarching guidance to influence corporate IT improvement investments to enable a robust, secure infrastructure for the enterprise-wide Digital Campaign
- LOE 1 – Integrated Environment – Models and Tools
  - GOAL: Provide an integrated digital environment (IDE) of models and tools for collaboration, analysis, and visualization across the functional domains of AF users
- LOE 2 – Standards, Data and Architecture
  - GOAL: Provide overarching guidance on the use of Government Reference Architectures (GRA) and related standards and datasets for use in an integrated digital environment for application at the enterprise and system levels.
- LOE 3 – Lifecycle Stategies and Processes
  - GOAL: Develop Life Cycle Strategies and Processes for Technology Transition, System Acquisition and Product Support using an Integrated Digital Environment (IDE), supporting lifecyle activities from concept development to disposal
- LOE 4 – Policy and Guidance
  - GOAL: Draft Recommended Changes for Digital Campaign
- LOE 5 – Workforce and Culture
  - GOAL: Shepherd the Command through the pivot of Digital Transformation through a deliberate change management approach, including conducting a stakeholder analysis, creating messaging timelines/modes, driving continual leadership engagement, conducting needs analysis, and partnering with experts to identify and fill workforce gaps

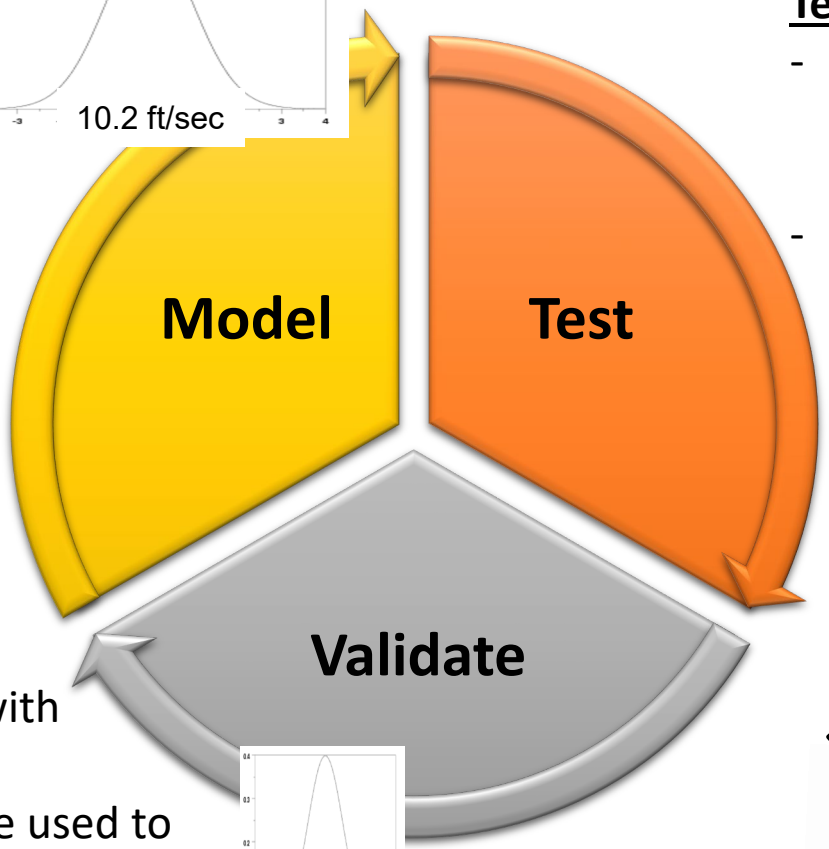
AFTC CURRENT USE OF DIGITAL ENGINEERING

M&S Integration with T&E

Model

- Models are used to predict system performance and characteristics
- Model iterations allow refinement of system design



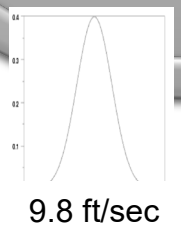


Test

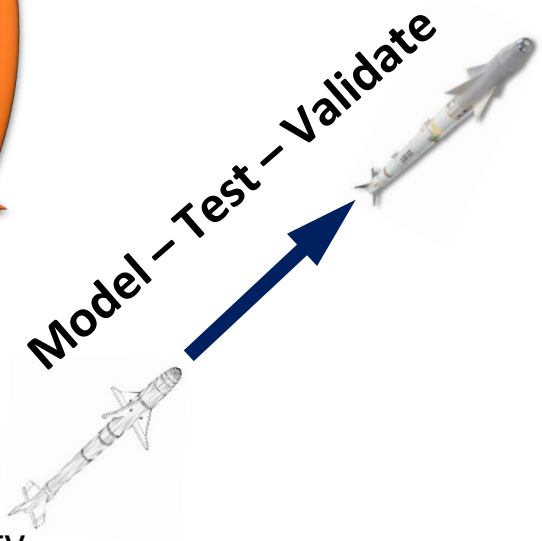
- Tests demonstrate system performance and characteristics
- Test planners use models to help optimize the test campaign

Validate

- Models are validated with limited test data
- Updated models can be used to refine the design or support other M&S requirements



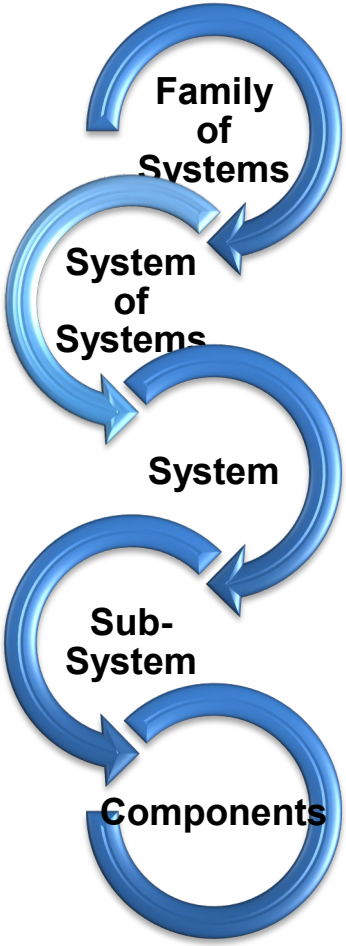
Improved estimate
Reduced uncertainty



A model without validation is just a cool video game

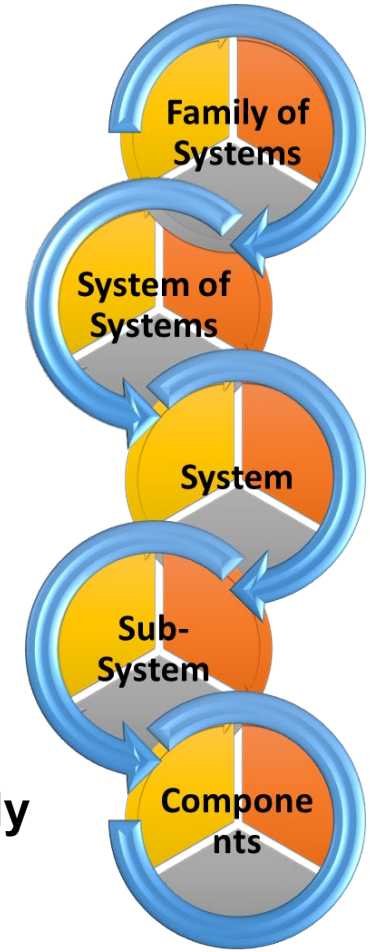
Increasing Design Detail

- **Model Based Systems Engineering**
  - **Uses models with increasing levels of detail**
  - **Enables linking model results and interfaces between the models**



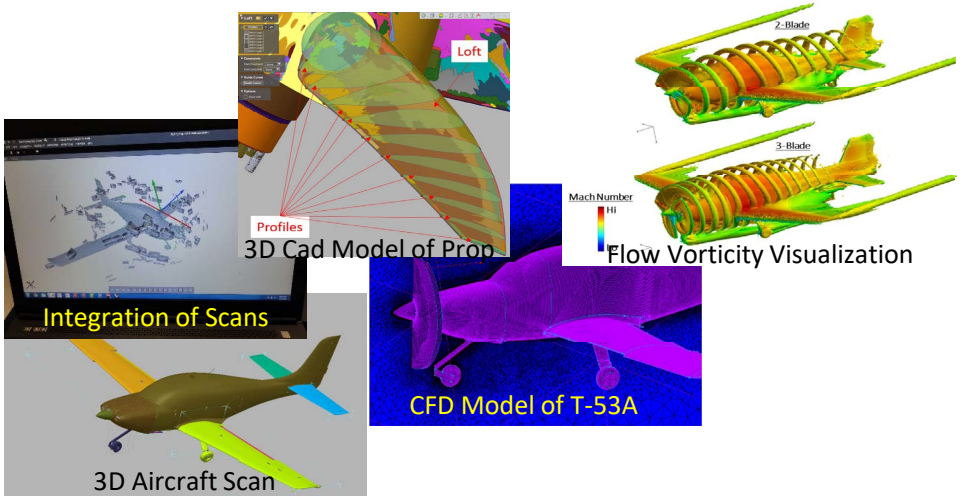
- **T&E**
  - **Tends to be isolated at individual levels with limited interaction or data sharing between levels**
  - **Feedback to models tends to be point-wise parameter based responses**

- **DE based T&E**
  - **Share T&E results laterally and vertically to improve T&E processes**
  - **Integrate T&E data into models for validation using the design-test-validate process**



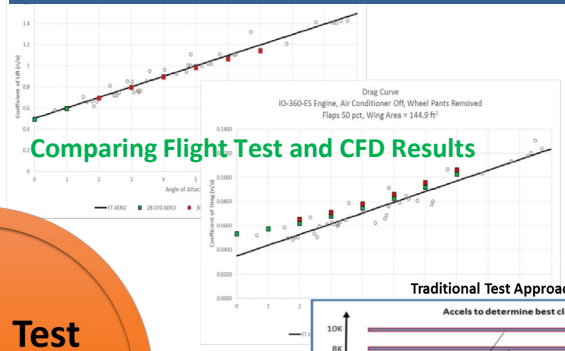
Performance Vignette

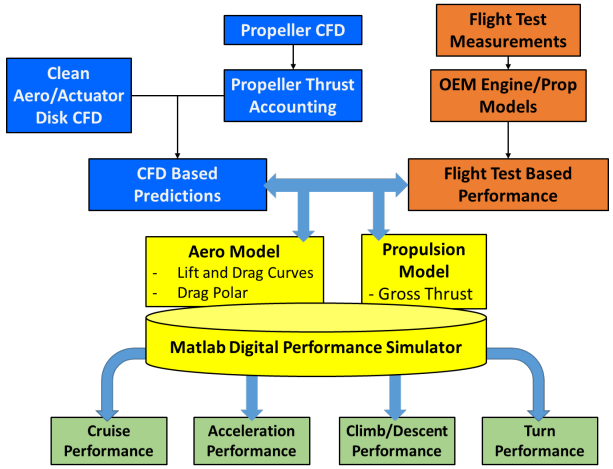
2016: Improve T-53A Aircraft Climb Performance

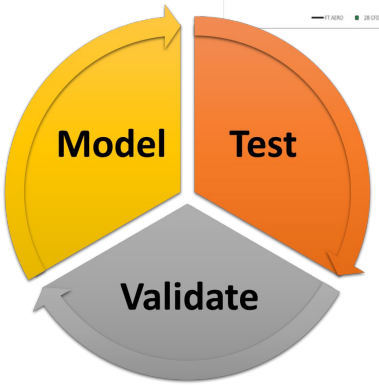


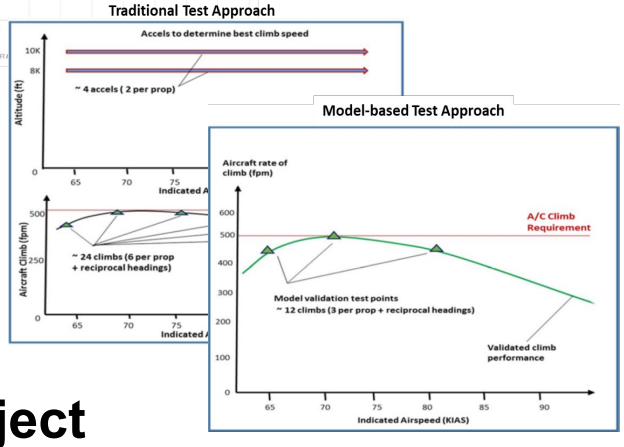
Key Results

1) Addressed PM concerns about value of propeller modification
2) Demonstrated value of model-based test approach
   - Delivered a validated model and reduced flight test requirements







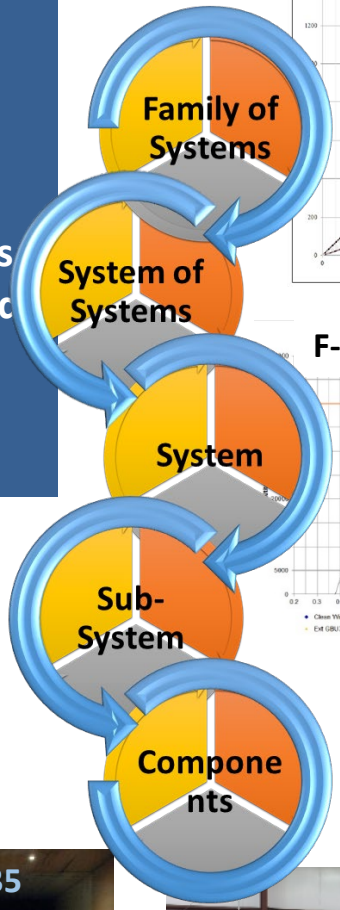


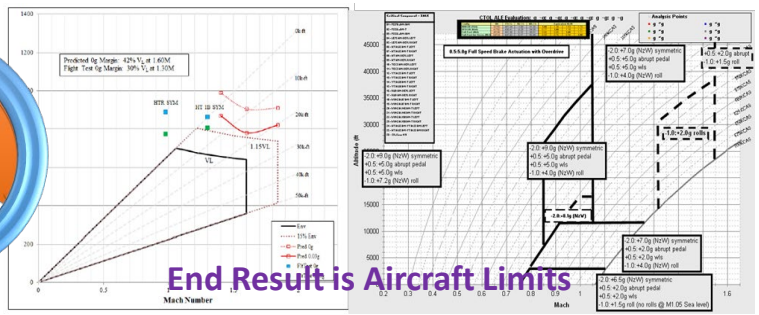
Combined 412TW/AEDC project

Structures Vignette

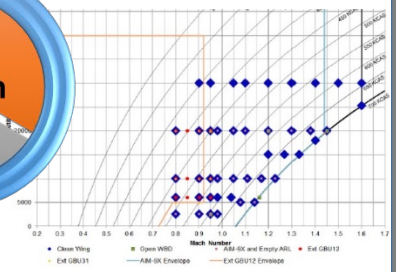
Structural Integrity Validation

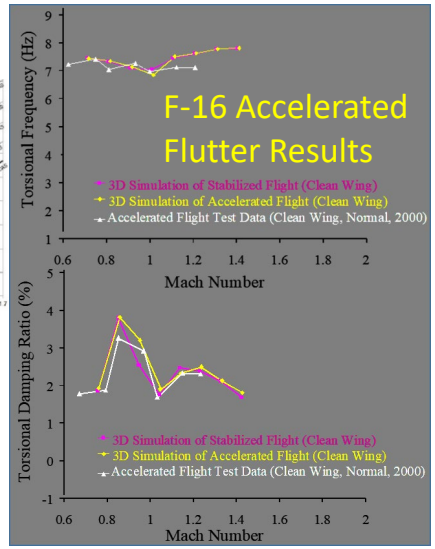
- Resource intensive engineering discipline
- Requires sophisticated computational fluids and finite element modeling
- Requires multiple full-scale test articles for strength, fatigue, live-fire, loads and flutter testing
- Component-level test results feed into family of systems as aircraft limits



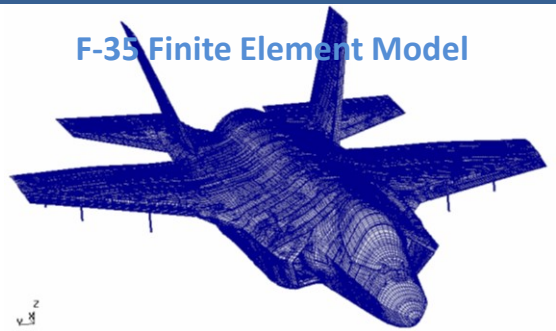


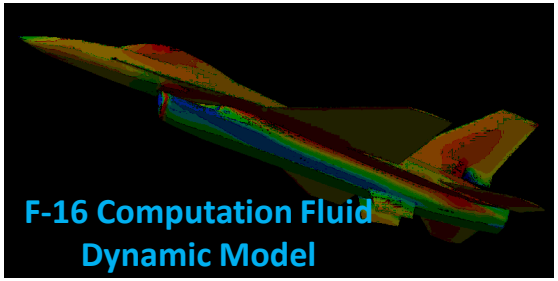
F-35 Flutter Test Plan





F-35 Finite Element Model





F-16 Computation Fluid Dynamic Model

F-35 Wind Tunnel

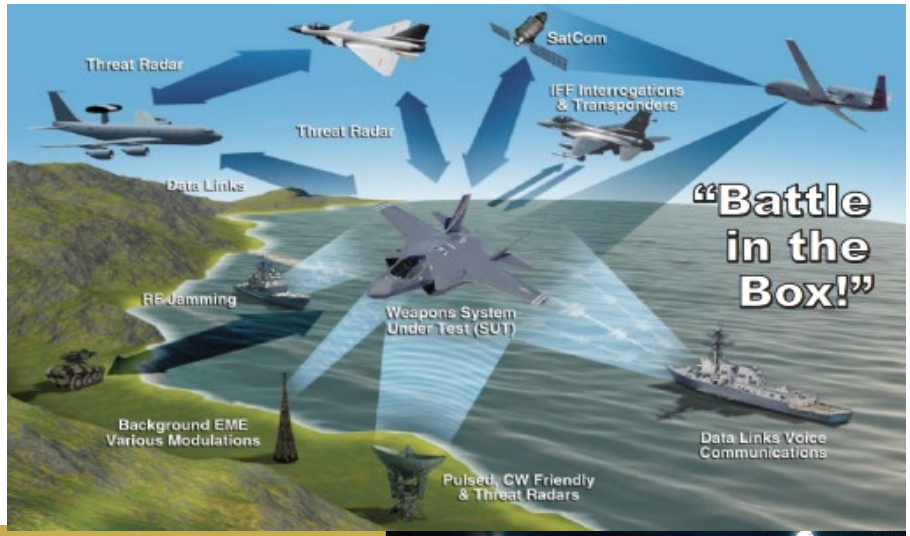
5GAT GVT

F-35 Static Loads Test

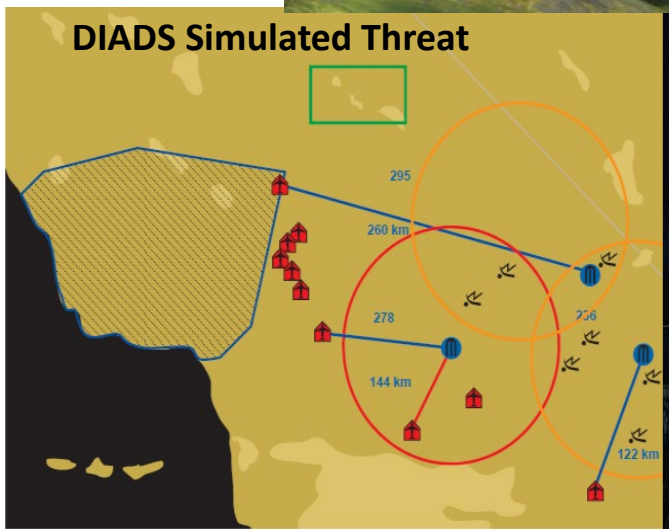
EW Vignette

Testing in a live environment not always possible

- Difficult to test Systems of Systems and Families of Systems
- Security considerations limit some operational configurations
- Increasing use of Live-Virtual-Constructive environments in distributed facilities



Joint Simulation Environment

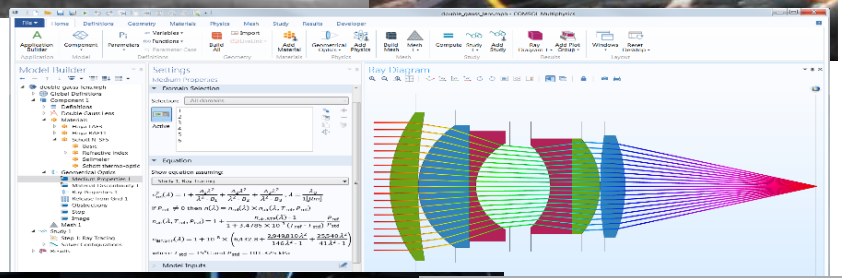


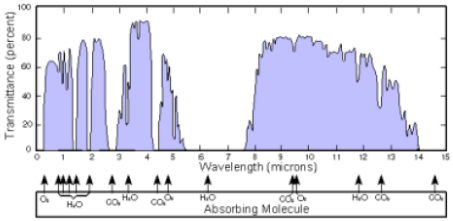
Testing, Advanced Training, TTP/CONOPS Development

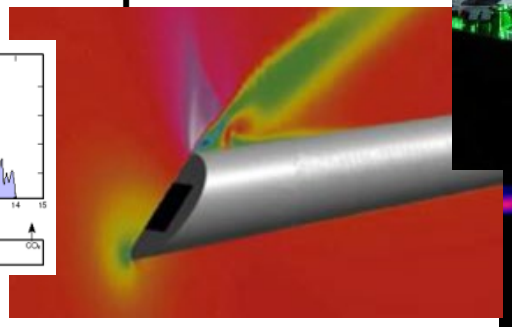
EO/IR Vignette

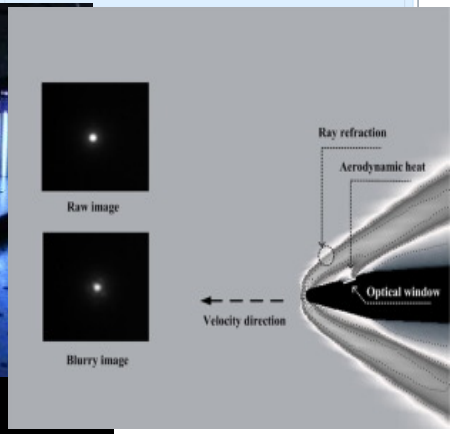
Open air testing is limited to narrow set of conditions

- EO/IR field is loaded with variables and highly multi-disciplinary complex physics
- Can't separate system performance/human performance/target signature/atmospherics
- Can't test against certain threats in varying atmospherics/environments
- Develop & integrate various novel truth measurements systems & targets, advanced M&S, lab measurements, open-air T&E, expertise, partnerships, etc… for novel customer solutions & products
- Predict performance in areas that are otherwise open-air test prohibitive









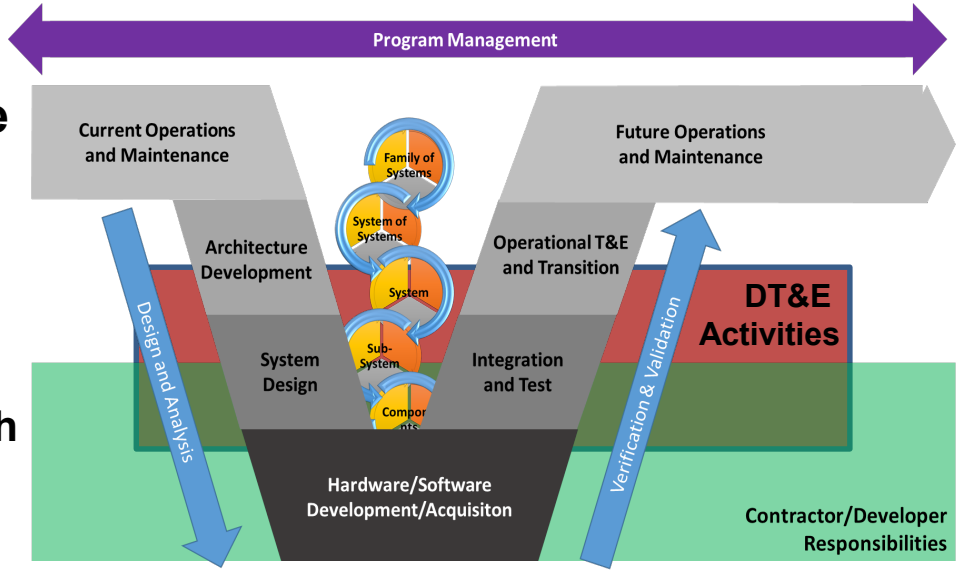
T&E, M&S, Integrated DT/OT, TTP/CONOPS Development

Advanced Products That Support SPO & Warfighter across broad Envelope of Threats & Environments

VISION: T&E IN DIGITAL ENGINEERING

Vision: T&E in Digital Engineering

- **Two levels of digital tools**
  - **MBSE and Government Reference Architectures; e.g., Teamcenter**
  - **Detailed engineering design models**
    - **May be contractor-developed**
    - **Programs and testers interact with these models and data**
- **Need to do <u>all</u> of the "V" not just the top part**



- **T&E provides value in the interface between these levels of tools by:**
  - **Sharing test data (authoritative source) and model results**
  - **Validating models**
  - **Integrating data sets up and down the "V" to minimize duplication**

T&E provides **decision quality** information and knowledge **throughout** the acquisition process, not just a report at the end

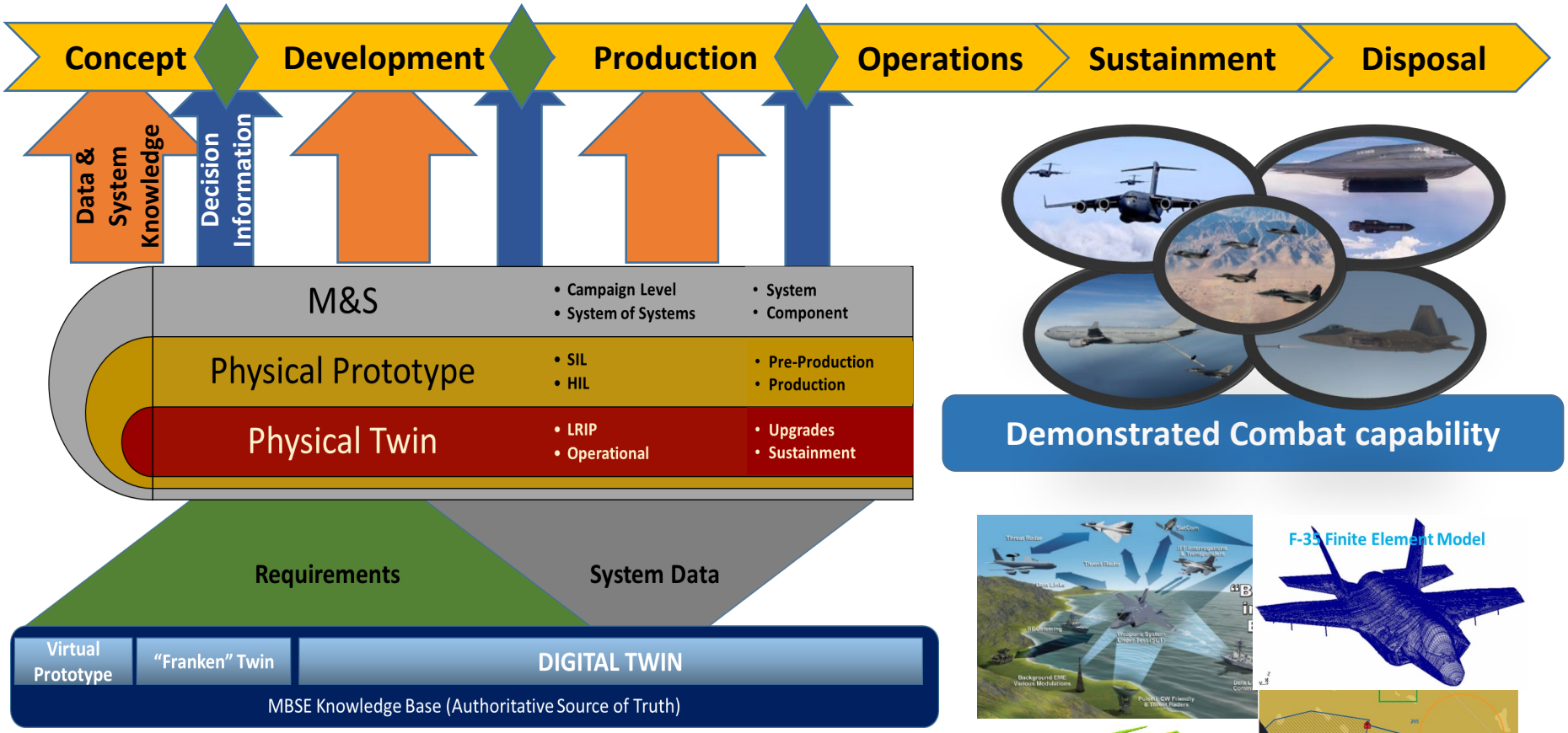
Vision: Benefits to Programs

- Internally to T&E, managing and leveraging the tremendous amount of technical data and system knowledge produced by T&E to:
  - Improve T&E processes
  - Improve uncertainty quantification/reduce technical risk
  - Help reduce fielding timelines
- Externally, integrating with the larger DE campaign to help validate technical models to provide a validated baseline for the weapon system lifecycle sustainment

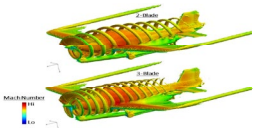
Bottom Line:

- More efficient and effective T&E
- Improved uncertainty quantification for technical performance measures to better inform risk-based decision making
- Validation of models for long-term use and reuse

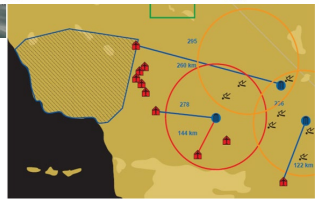
Vision: T&E Marries the Digital Twin w/ the Physical System



Demonstrated Combat capability



Flow Vorticity Visualization



Validated Models

A model without validation is just a cool video game

Vision: T&E Transformation Enabled By Digital Engineering

DoD Digital Engineering Strategy	T&E Transformations	Purpose of T&E (DoDD 5000.1 E1.11)
Formalize the development, integration, and use of models to inform enterprise and program decision making	1. Transform T&E from a data source for validating a code to a knowledge source for developing and calibrating an authoritative digital surrogate model	Integrate with M&S to facilitate learning, assess technology maturity and interoperability, facilitate integration into fielded forces
Provide an enduring, authoritative source of truth	2. Use T&E calibrated surrogates to provide credible Quantified Margins and Uncertainties (QMU) to support Risk Informed Decision Analytics	Provide essential information to decision makers
Incorporate technological innovation to improve the engineering practice	3. Define the value of T&E in terms of quantified and managed progression of TPMs to meet requirements	Assess attainment of technical performance parameters (TPMs)
	4. Use Bayesian inference to determine best course of testing to master risk and optimize value	Confirm performance against documented capability needs and adversary capabilities
Establish a supporting infrastructure and environment to perform activities, collaborate and communicate across stakeholders	5. Transform from linear, calendar- and document-driven processes to dynamic, model-based, processes including a Digital Test & Evaluation Master Plan (TEMP) and "Digital Critical Decisions"	Determine whether systems are operationally effective and suitable, survivable, and safe for intended use
Transform the culture and work		

The key to transforming T&E through Digital Engineering is to think *DIGITALLY*, not digitized

Source: Dr. Ed Kraft, *New Digital Engineering Enabled Systems and Mission Engineering Performance Measures,*, SoS Engineering Collaborators Information Exchange Webinar, 5 May 2020.

AFTC SUPPORT TO THE AFMC DIGITAL CAMPAIGN

AFTC Support to the Digital Campaign

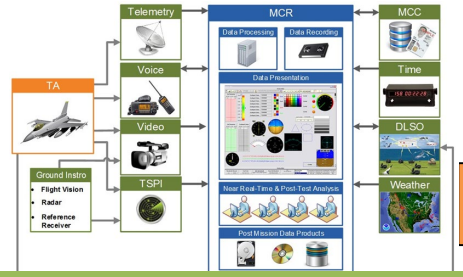
Participating in all LOEs with multiple representatives in each:

- **LOE 0 – Integrated Environment - IT Infrastructure**
  - Key to a digitally connected acquisition process - T&E will need larger bandwidth, storage and sharing capabilities of data
- **LOE 1 – Integrated Environment – Models and Tools**
  - T&E must transform from a data source for validation to a knowledge source for calibrating a digital twin
- **LOE 2 – Standards, Data and Architecture**
  - Identifying a Govt Reference Architecture for T&E data
  - Identifying T&E data requirements for airworthiness & cybersecurity
  - Developing robust lexicon that builds on previous efforts
- **LOE 3 – Lifecycle Strategies and Processes**
  - Reinvent processes to leverage digital connectivity of trusted data/knowledge
  - For example, not just a digitized TEMP but a dynamically coupled document to the requirements, MBSE and the digital twin
- **LOE 4 – Policy and Guidance**
  - Need government-owned technical baseline and data rights for models across the lifecycle
- **LOE 5 – Workforce and Culture**
  - Acquire new skill sets such as data science and enhance existing skill sets such as statistical analysis

Building on 70 years of pioneering new technology for the nation

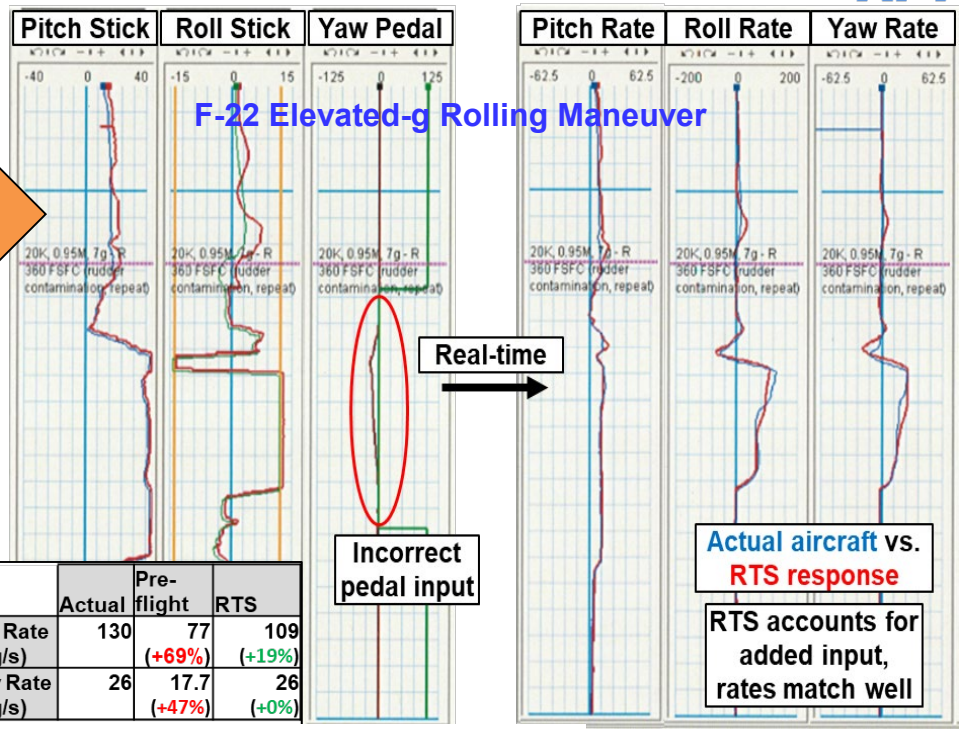
WAY FORWARD FOR T&E IN A DE CAMPAIGN

Current AFTC Digital Engineering Investments



Real-Time Mission Control Room Upgrades

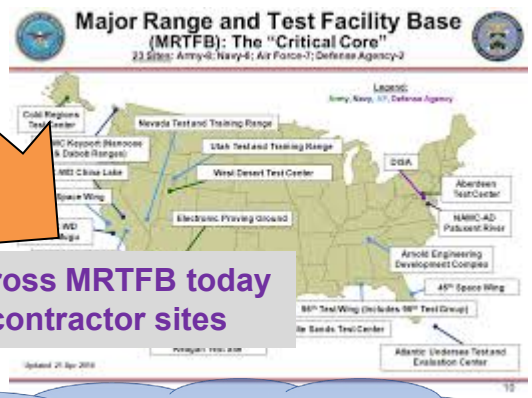
Real-Time Simulations



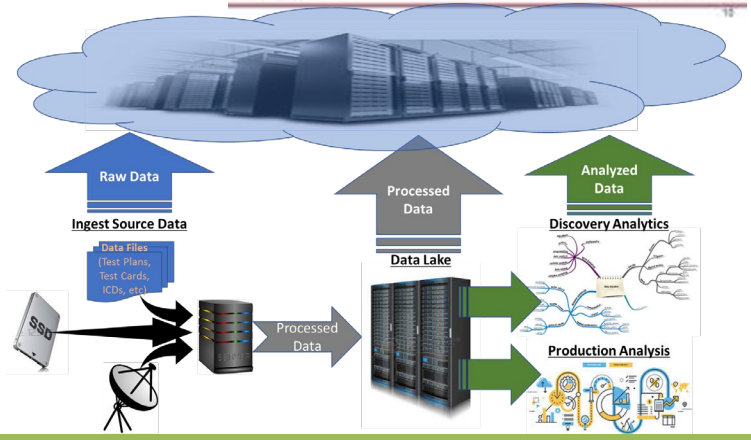
	Actual	Pre-flight	RTS
Roll Rate (deg/s)	130	77 (+69%)	109 (+19%)
Yaw Rate (deg/s)	26	17.7 (+47%)	26 (+0%)

RTS enabled continuation of testing versus returning home for further analysis

Distributed Test Operations



Share data across MRTFB today
Near future – contractor sites



Post-Test Knowledge Management and Data Analytics

Get more knowledge from the test data we already collect – faster!

What's Next?

- Integrate T&E processes with AFMC DE Campaign processes
  - T&E and data requirements flow from MBSE and digital TEMP
    - T&E does not own requirements, recommend best practices to meet requirements
  - Data collected in format "relevant to users of test data:
    - Decision makers
    - Certifications
    - Integrity programs
    - Operational users
  - Advanced tools to support integrated evaluations and improved model validation and calibration
- AFTC POM submission to implement and sustain T&E Digital Engineering workforce, tools, and infrastructure
  - Builds on existing T&E investments to accelerate weapons system fielding

Questions