



AFRL

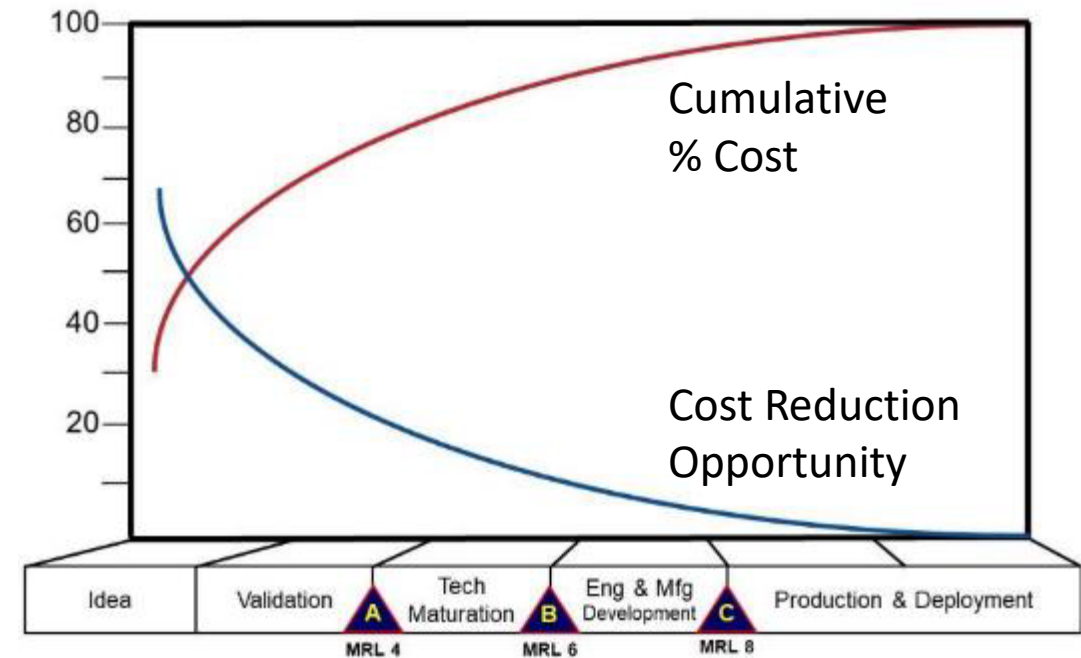
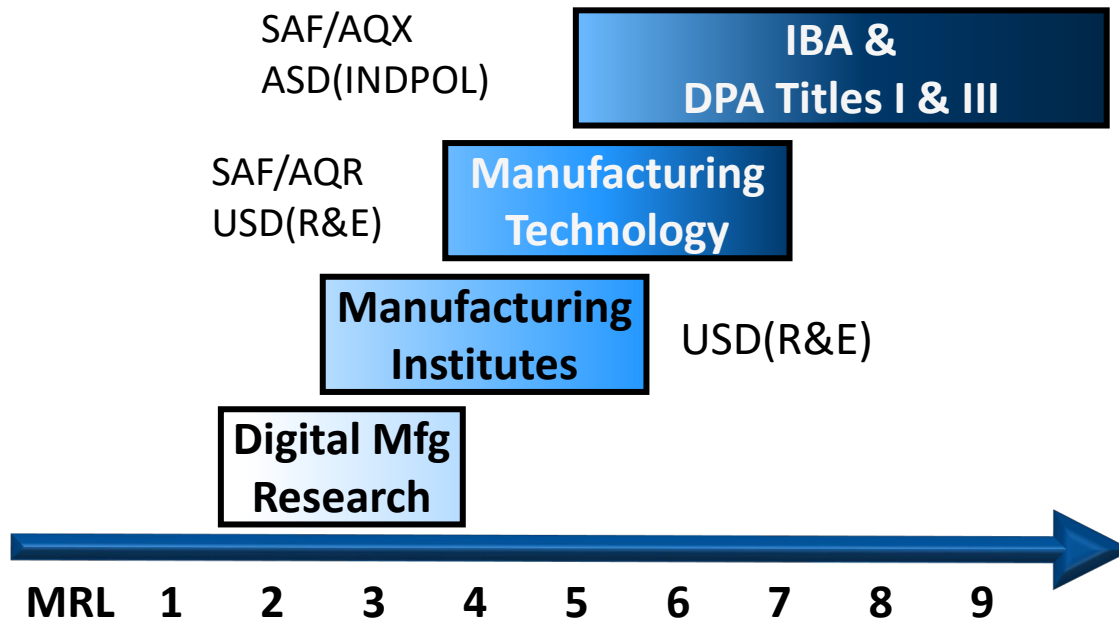
MODEL-BASED QUALITY ASSURANCE: A KEY ENABLER TO SCALE AND SPEED

WILLIAM "BILL" BERNSTEIN, PHD
TECHNICAL AREA LEAD, DIGITAL MATERIALS AND MANUFACTURING
MANUFACTURING, INDUSTRIAL TECHNOLOGIES, AND ENERGY DIVISIO
APRIL 2026



AFRL/RXM | Manufacturing and Industrial Technologies Division

- Significant opportunity to realize cost savings by engaging with stakeholders early to promote manufacturable designs and ensure the industrial base will be ready to produce
- Responsive to acquisition programs across the development, production and sustainment lifecycle



AFRL/RXM uniquely addresses manufacturing & industrial base challenges

- across manufacturing development lifecycle
- from process conception through full rate production
- across the spectrum of aerospace technology
- for both acquisition and sustainment

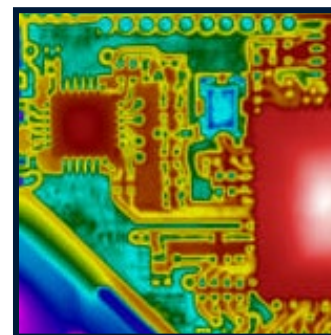
Materials and Manufacturing (M&M) Technical Strategy Areas



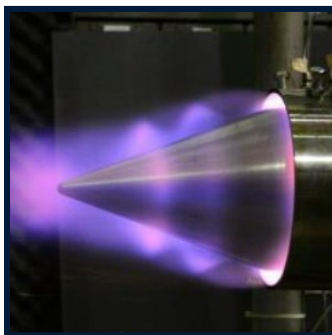
**Lightweight
Structures
M&M**



**Agile
Mfg**



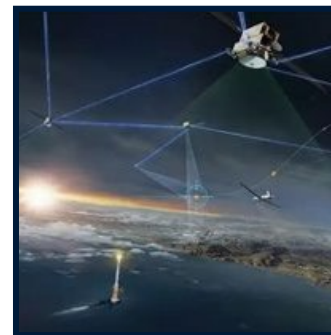
**Spectrum
Warefare
M&M**



**M&M for
High Speed
Systems**



**Digital
Materials
and Mfg**

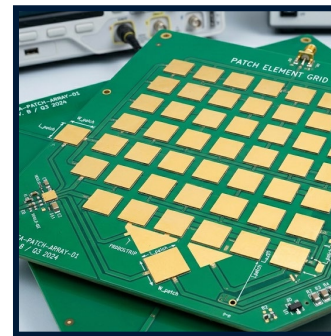


**Advanced
C4I
M&M**



**Space-Env
Unique
M&M**

pervasive



**ISR M&M:
Advanced
and Low
SWAP-C**



Technology enablers

Standards Development

Workforce Development

Digital Airworthiness

Digital Advanced Materials

Design Optimization

Process Modeling/Simulation

Non-tech enablers

Incentivization Models

Contr. Terms and Conditions

Digital Sustainment Models

ATO / IATT

Cultural Readiness

Model-Based Quality Assurance

Interoperability

Information Modeling

Geometry & Topology

Standards Compliance

Digital Thread



Secure Collaboration for Supply Networks

Anomaly Detection

Smart Mfg Contracts

Zero Trust Architecture

Big Data Analytics

Multi-party encryption



Model-Based Acceptance

Digital Maturity towards Autonomy

Distr. Data Exchange

Maturity Assessment

Inconsistency Identify

Verification & Validation

AI Integration



Supply Network Visibility



Goals

- 1) Accelerate weapon system delivery through model-based acceptance
- 2) Establish end-to-end supply network visibility
- 3) Remove human latency in production to achieve agility and flexibility

Competencies

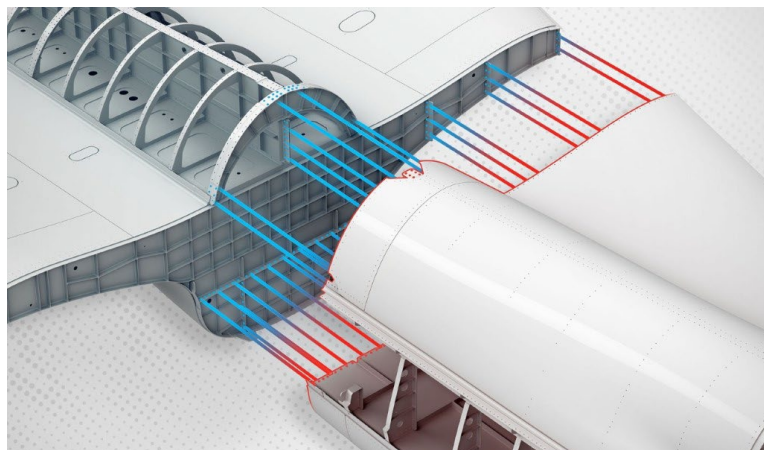
- Information Modeling and Systems Thinking
- Multi-Modal Data Registration (Digital Thread)
- Zero Trust Architectures (Mfg Contracts)
- Multi-Party Model Encryption (Collaboration)
- Multi-Domain Optimization (Decision Making)
- Verification, Validation, and Uncertainty Quantification



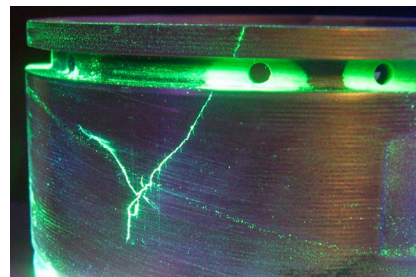
Applications / Demand Signals

- Model-Based Quality Assurance (MBQA)
- Virtual / Surrogate Qualification to Expedite System Acceptance
- Anomaly Understanding and Opportunity Discovery across Supply Networks
- Non-Conformance and Inconsistency Identification across Distributed Production

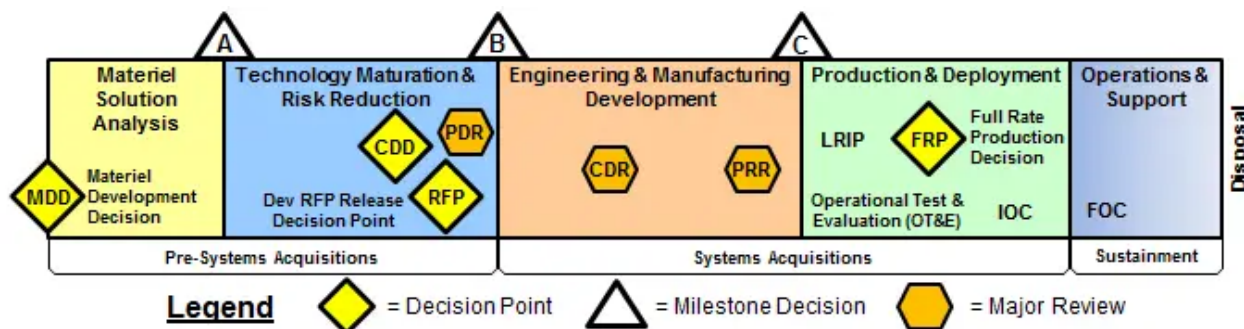
Recent Use Cases of (Particular) Interest



Full-Sized Determinant Assembly (FSDA)



Failure Analysis at Sustainment



Acquisition Support / Data Rights



Industry 4.0 Standards Activities

Challenge:

Harmonizing Industry 4.0 standards at scale



Lu, Y., et al., 2016. Current standards landscape for smart manufacturing systems. *NIST, NISTIR, 8107*.

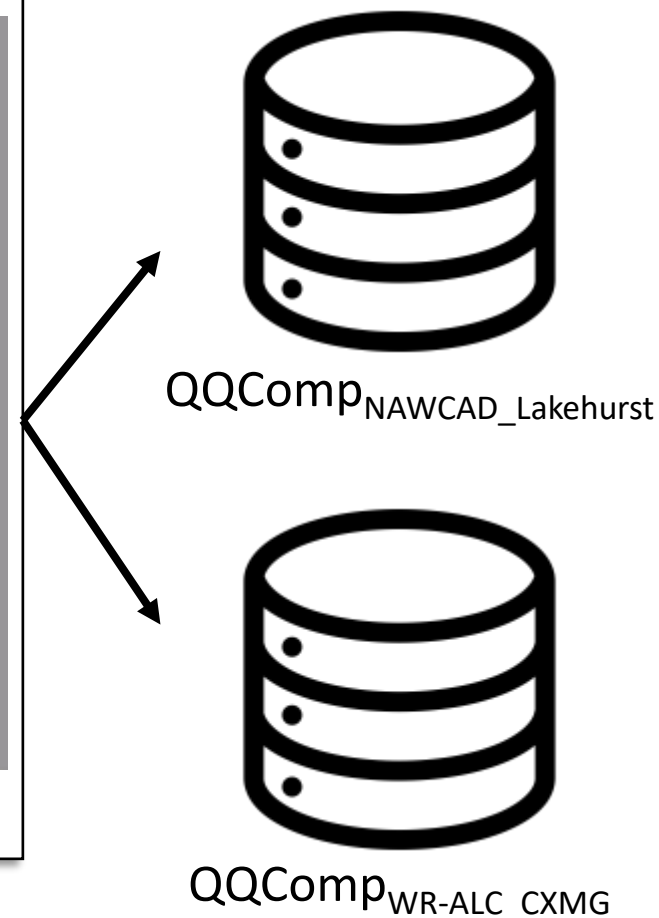
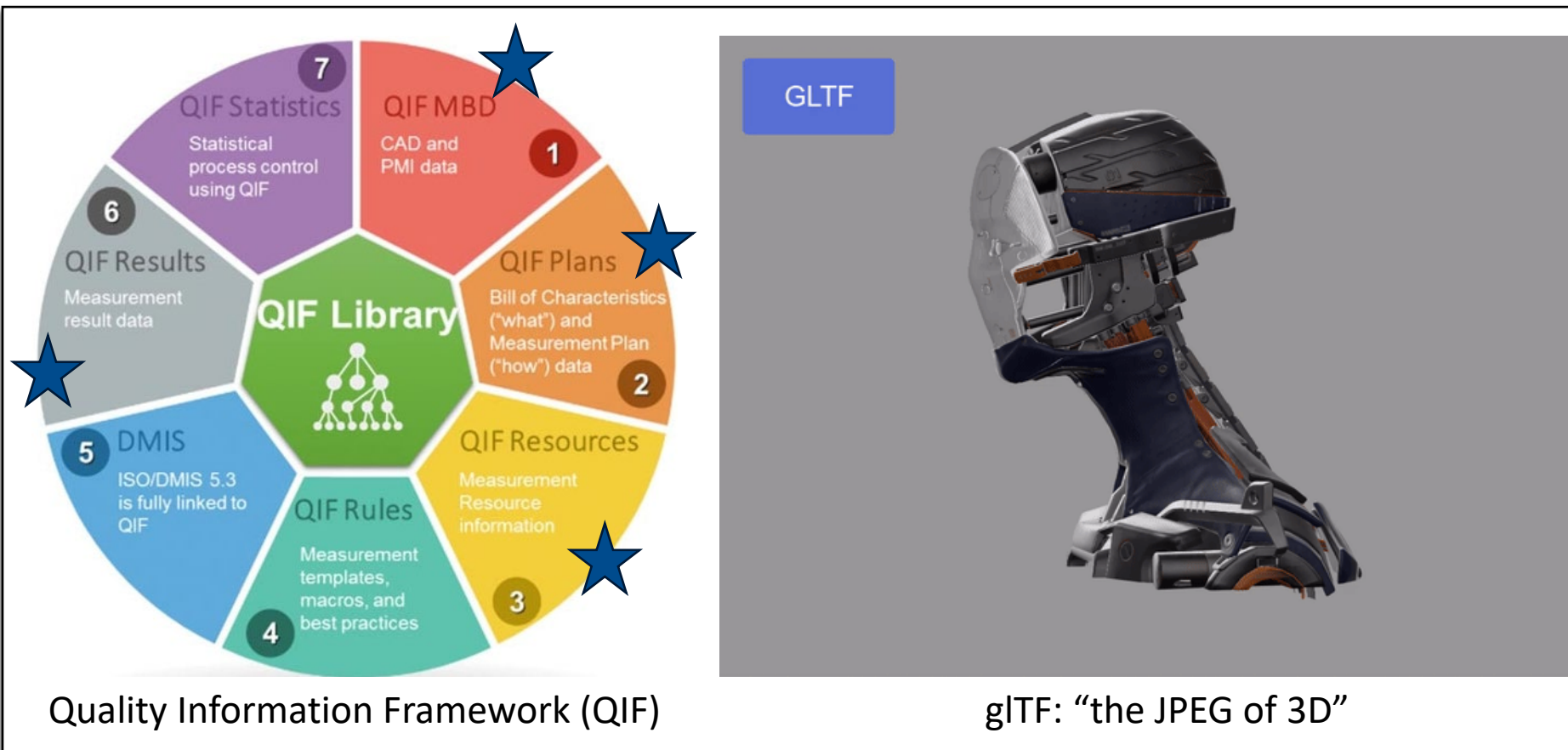


Selected Project Highlights

- *QQComp: Quality Digital Thread
- *TDP Modernization: Linking Data Back to MBD
- *Supply Chain Illumination



Link DoW quality information to lightweight geometric models
Curate this digital thread into a government-owned database



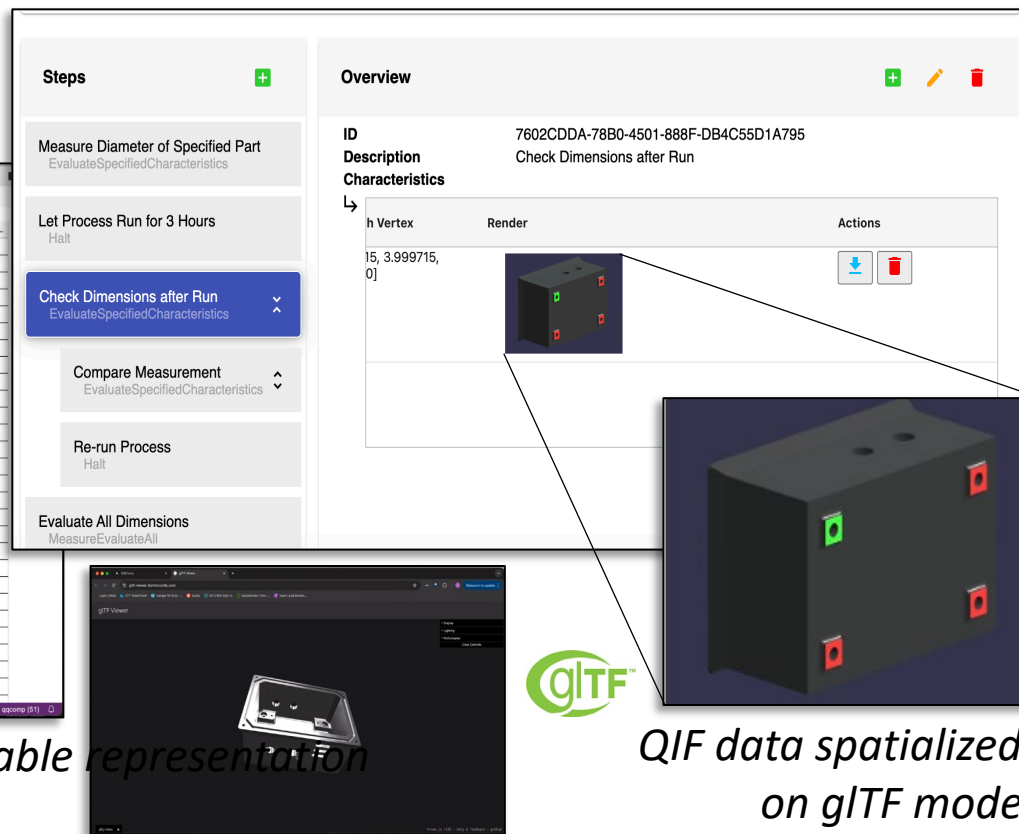


Link DoW quality information to lightweight geometric models
Curate this digital thread into a government-owned database

CONNECTIONS										
SERVERS										
db.ExternalFile_3 - QCComp Demo										
db.Product_3 - QCComp Demo										
db.Characteristic_3 - QCComp Demo										
db.Characteristic_1 - externalFile										
ID	productID	glTFMeshName	characteristic1	characteristic1	characteristic1	characteristic1	externalFile			
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Ln 1 Col 1 Spaces 4 UTF-8 CR/LF MSOIA Localhost: qccomp (51)

Database linking origin PMI to AR-amenable representation



Steps

- Measure Diameter of Specified Part
EvaluateSpecifiedCharacteristics
- Let Process Run for 3 Hours
Halt
- Check Dimensions after Run
EvaluateSpecifiedCharacteristics
- Compare Measurement
EvaluateSpecifiedCharacteristics
- Re-run Process
Halt
- Evaluate All Dimensions
MeasureEvaluateAll

Overview

ID: 7602CDDA-78B0-4501-888F-DB4C55D1A795
Description: Check Dimensions after Run

Characteristics

h Vertex	Render	Actions
15, 3.999715, 0]		

QIF data spatialized on glTF model

Supported by



Partners

Naval Information Warfare Center



PACIFIC

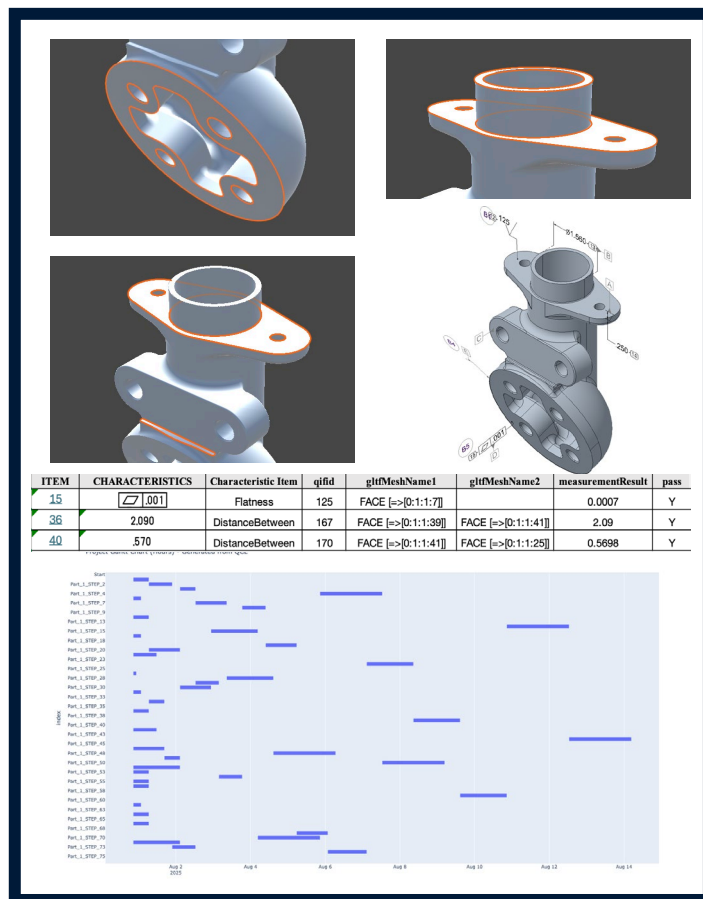


ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER



WARFARE CENTERS
CRANE

QQComp Transition: NAWCAD Lakehurst & WR-ALC



NAWCAD Lakehurst anticipates a 10% schedule efficiency for inspection processes

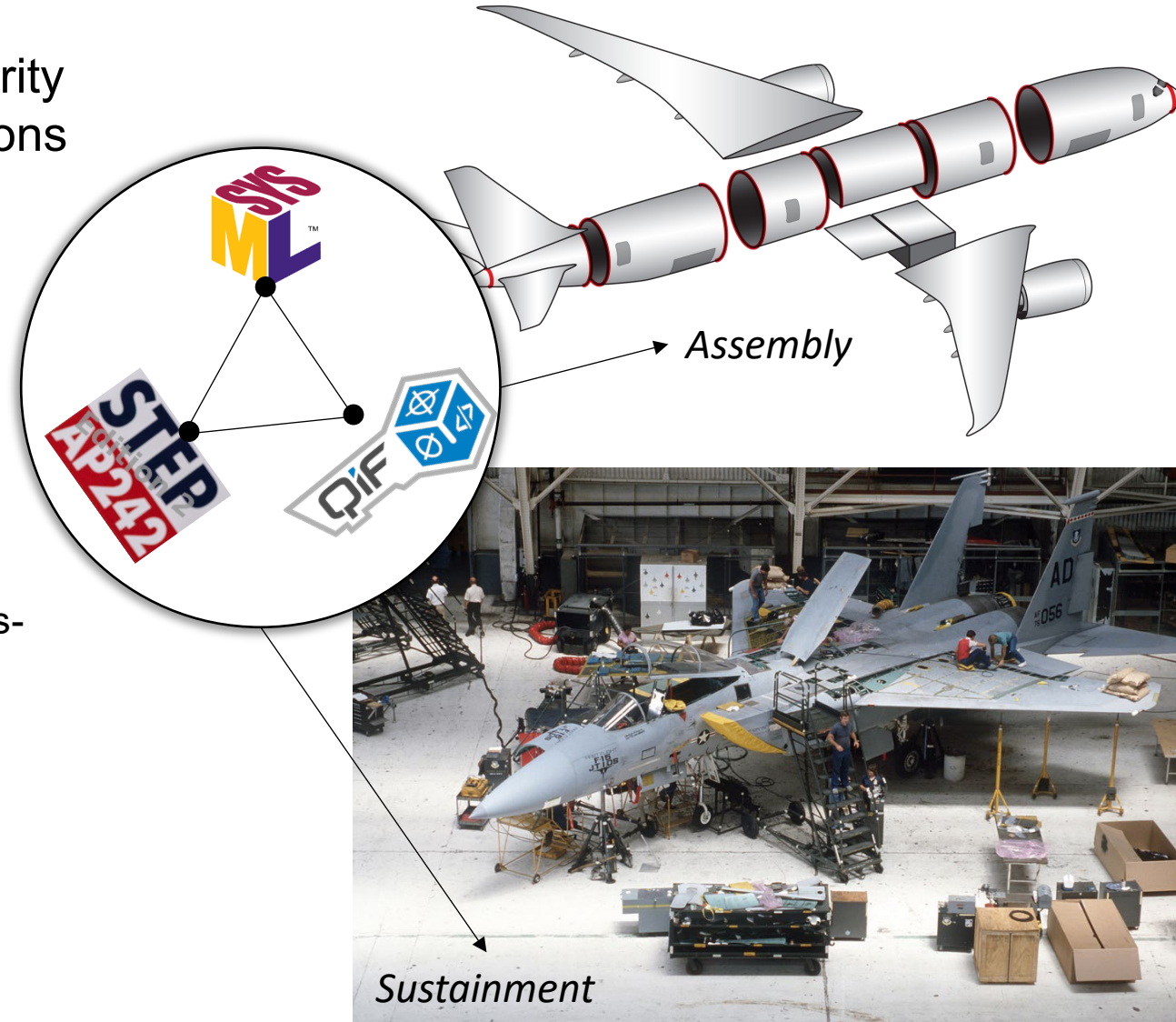


WR-ALC anticipates an 80% efficiency on inspection planning on test robotic inspection cell



Technical Data Modernization for As-Built Data

- MBE standards have reached adequate maturity to warrant large-scale testing via demonstrations
- DAF-relevant assembly and sustainment activities would benefit from better data exchange practices
- DAF acquisition service requires guidance in how/what data to purchase up-front
- Two use cases:
 - Project 1: Advanced data linking of part/assembly as-built data to facilitate shim-less assembly
 - Project 2: Better data curation for non-destructive inspection (NDI) in sustainment





Unirep

as-designed **CAD** **creo** **STEP AP242**

as-built **ASoT**

CAM **MT Connect** **as-executed**

CAI **as-inspected**

QIF

more about this effort tomorrow!

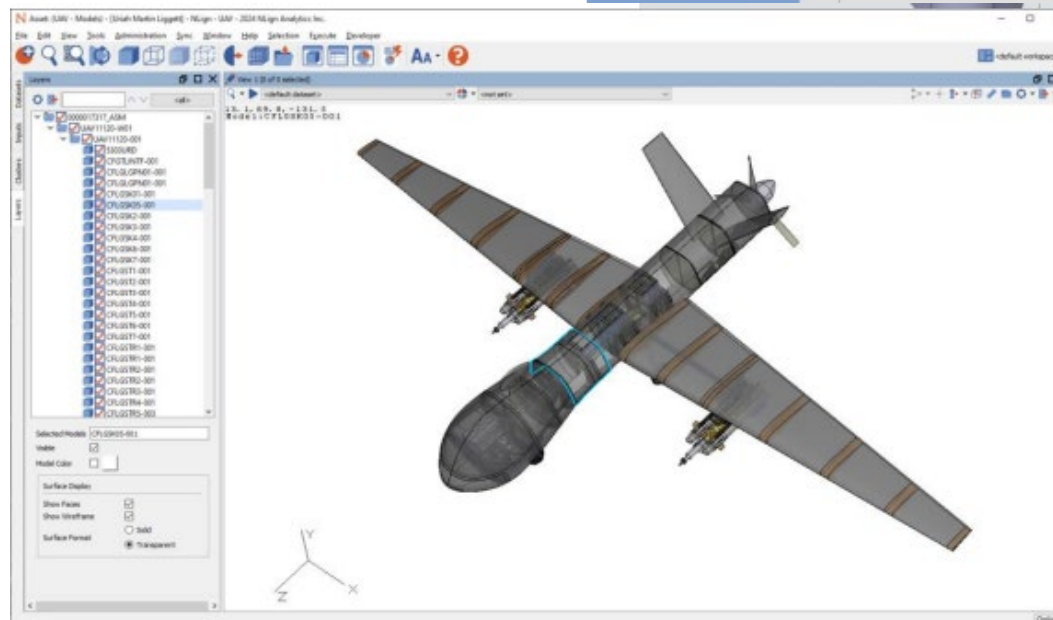
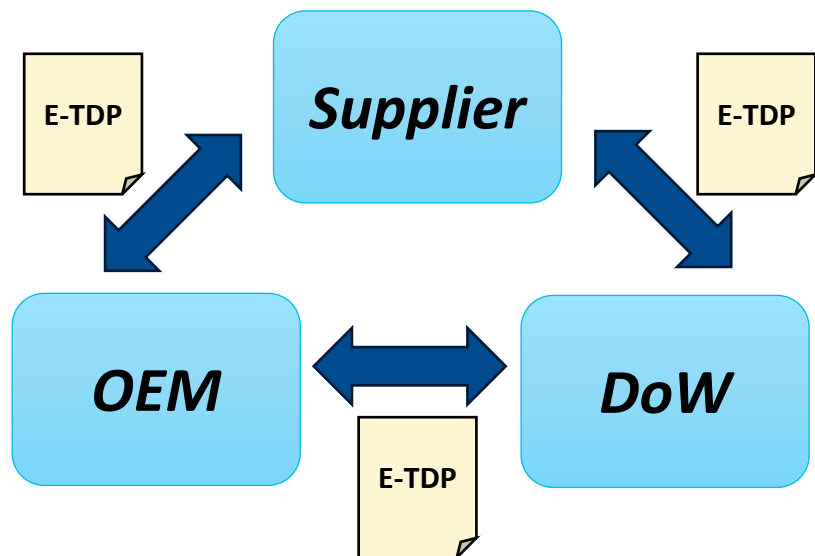
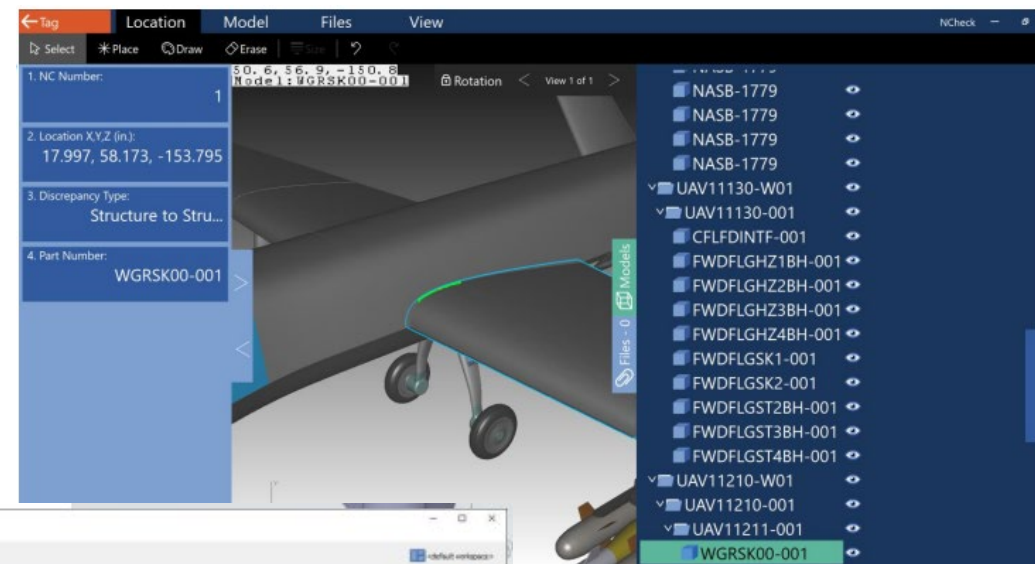
Learn more about this effort tomorrow!
Dr. Ben Urick, nVriate Inc. – 9:35am

TDP Project 2: Digital Twin for Sustainment

Key Digital Artifacts

Non-conformances (NC)	Requests for Variances (RV)
Serialized BOMs	Engineering Change Orders
Inspection Results	Actual Hole Locations

...



E-TDP Aware Systems

ETIMS

REMIS

FSID

NLign

Teamcenter

CAMS-FM

JEDMICS

AutoTAR

IMDS

MROI

NLIGN
ANALYTICS



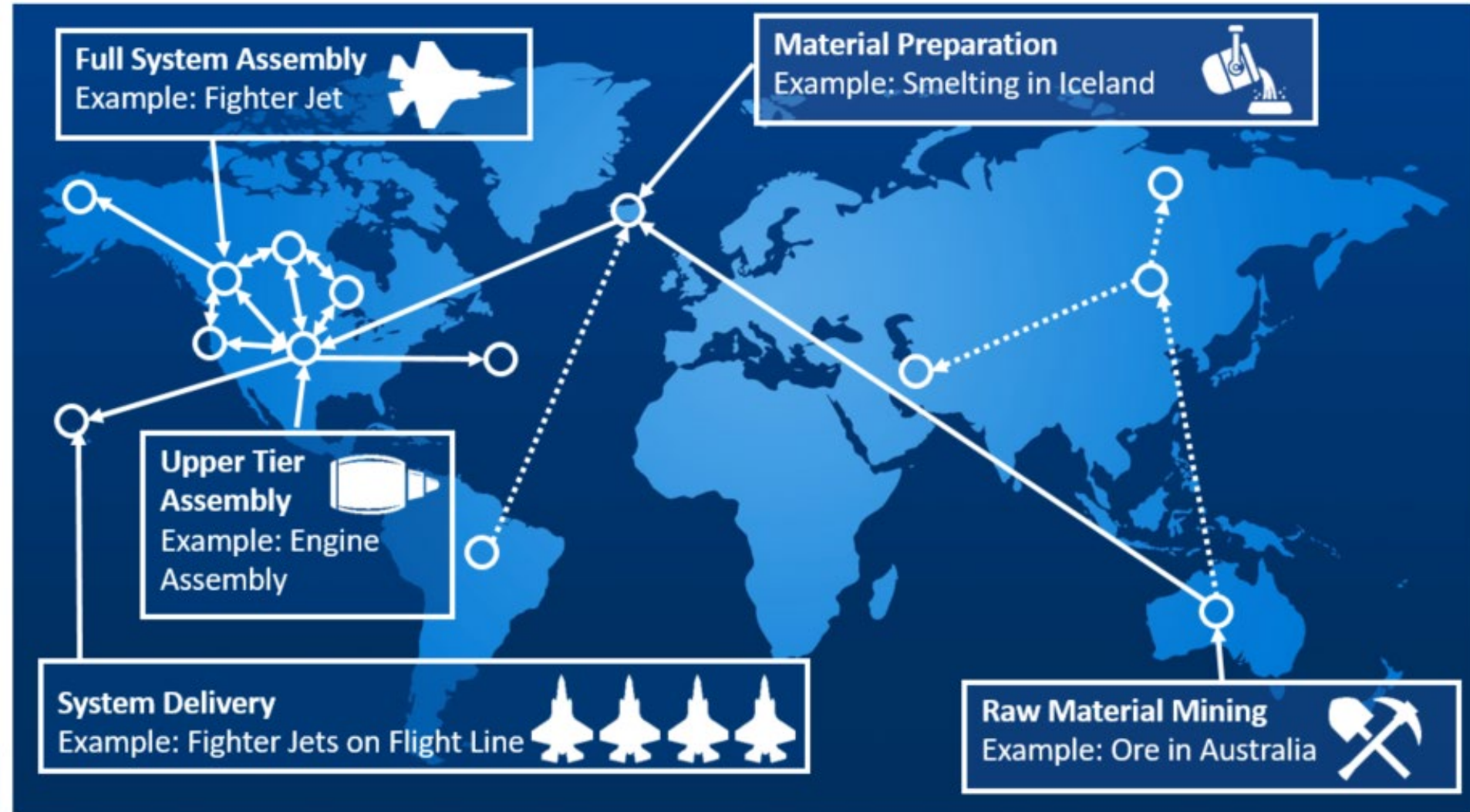
Scenario-based Predictive Outcomes for Real-World Events

Problem:

Existing supply chain data is stove-piped and isolation in ways that make predictive risk analysis impossible.

Objective:

Provide secure tools and data to illuminate fully-integrated supply chain information that can be mapped to specific assets or specific industry sources to conduct real-time, predictive risk analyses





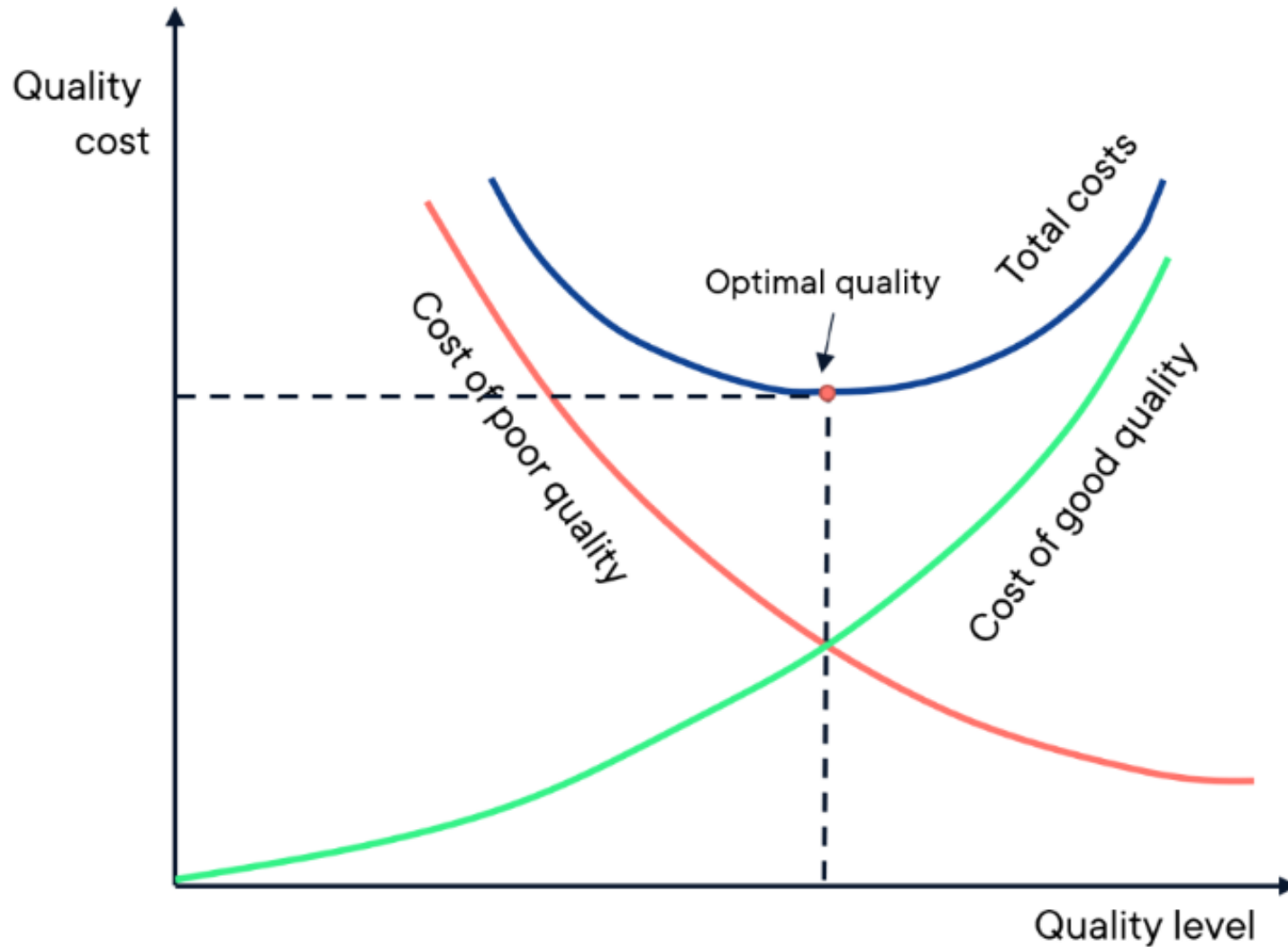
Looking Forward: DAF ManTech interest in facilitating surge

Context – Ready for Surge?

- Growing concerns over readiness for conflict
 - DIB shrinking; acquisition timelines unsupportable; excess capacity eliminated
 - Lack of centralized planning/direction
 - Recognition that “surge” will be required – but no clarity on that concept
- Industry has only begun to engage
 - High level policy guidance not (yet) actionable
 - No process to generate investment plans
 - Cannot be business as usual
 - Freedom’s Forge – inspirational, but...aspirational?
- Traditional acquisition process lacks scalability & flexibility
 - Stress test techno-licensing models?
 - Vertical integration obsolete?
 - Need to push from supply chains to supply networks



Model-Based Quality Assurance & Model-Based Acceptance



Incentivization models and cultural dynamics are undeniable.

- What is good enough?
- Risk aversion vs. required speed?
- Incentive OEMs to play in broader ecosystem?
- How to incentivize non-traditionals to engage?

Technical gaps still remain.

- How to VVUQ data across the supply network?

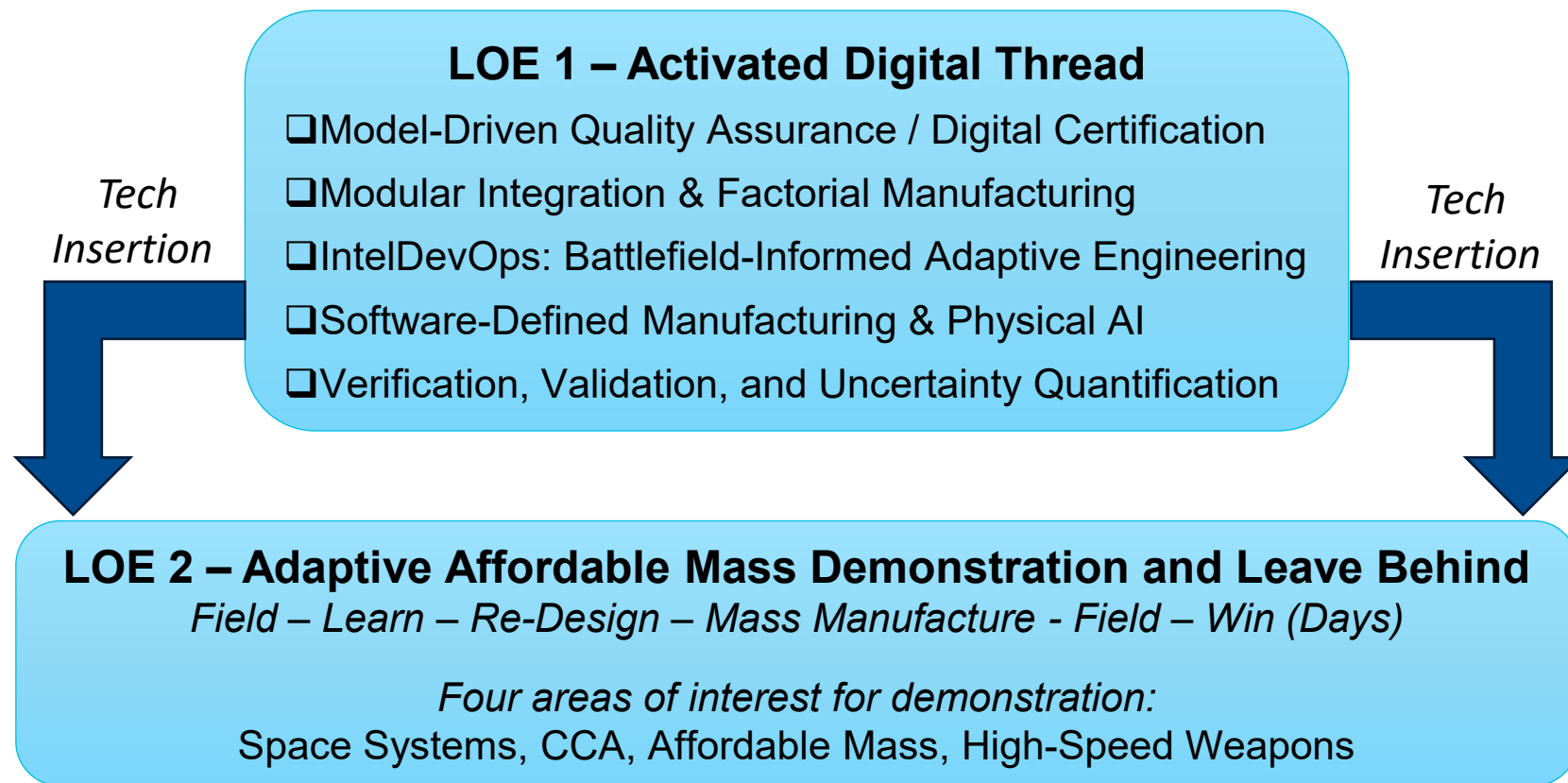


Endless Forge is Manufacturing-as-a-Service: a surge-capable, adaptive, resilient, and scalable manufacturing capability

AFRL



Continuous Battlefield Adaption is essential to effective military production!



**Endless Forge MAA
Open Solicitation**



Freedom's Forge Transforms into Endless Forge





Manufacturing Models Overview

Mass Production

CONTROL

Centralized, in-house

SCALE

High volume, standardized

FLEXIBILITY

Low - tooling investment

Contract Manufacturing

CONTROL

Distributed via contracts

SCALE

Variable, third-party capacity

FLEXIBILITY

Medium - supplier dependent

Manufacturing as a Service

CONTROL

API-driven, on-demand

SCALE

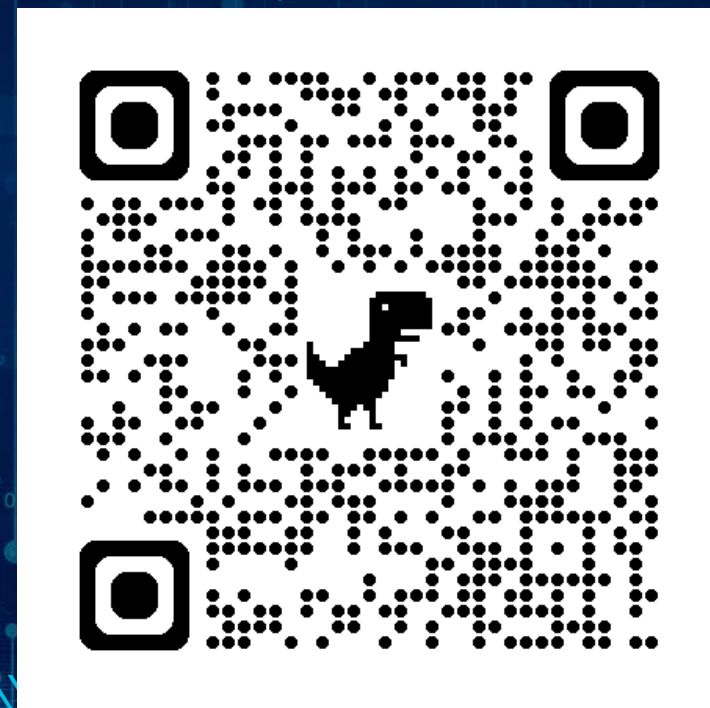
Elastic, network capacity

FLEXIBILITY

High - rapid iteration



QUESTIONS?



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**Endless Forge MAA
Open Solicitation**