Homeland Defense & Security
Information Analysis Center

Digital Twins for Defense Applications

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& Innovative Design

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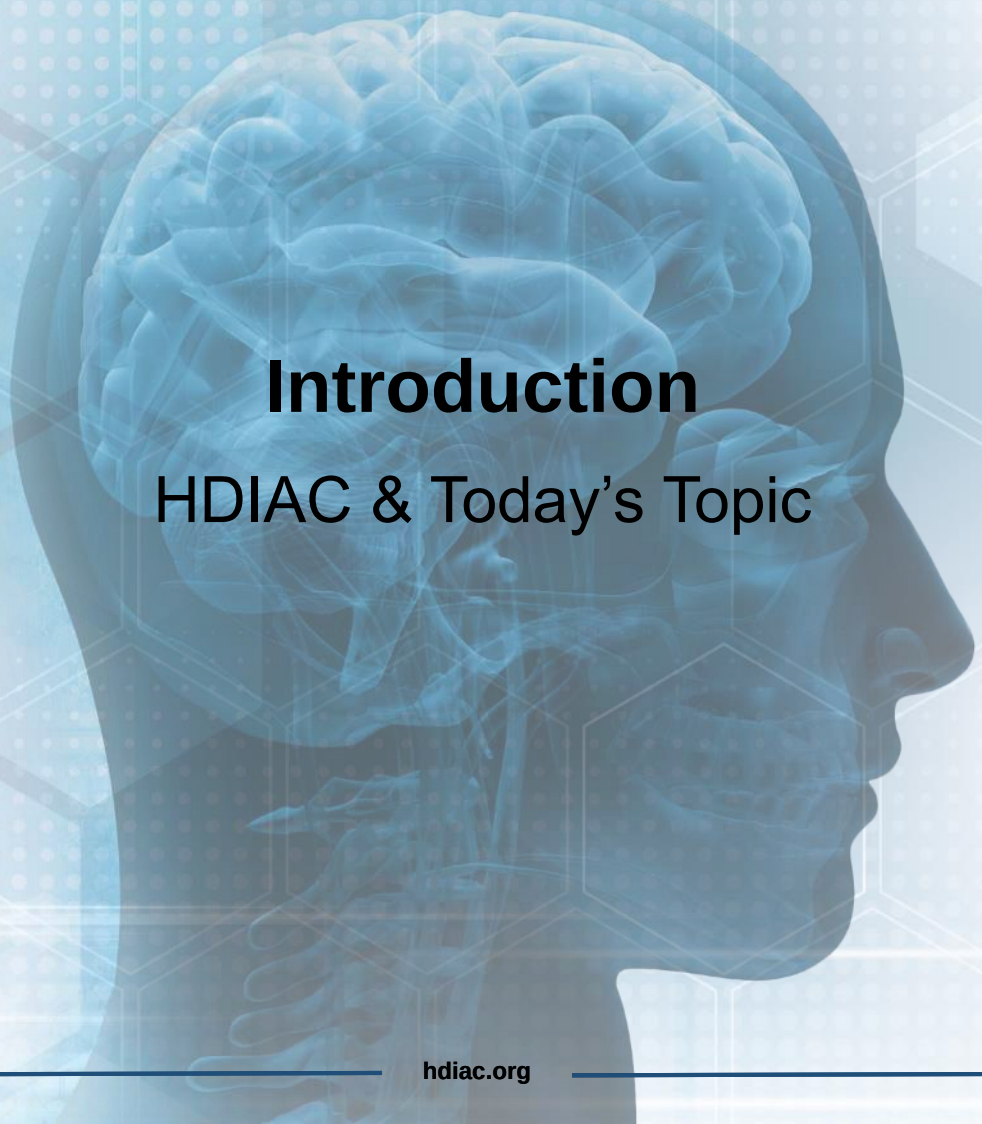
The views presented are those of the speaker and do not necessarily represent the views of DoD or its components.



Introduction

HDIAC & Today's Topic

HDIAC Overview

What is the Homeland Defense & Security Information Analysis Center (HDIAC)?

One of three Department of Defense (DoD) Information Analysis Centers managed by DoDIAC at Fort Belvoir.

HDIAC is responsible for acquiring, analyzing, and disseminating relevant scientific and technical information, in each of its eight focus areas, in support of the DoD and U.S. government research and development (R&D) activities.

HDIAC's Mission

HDIAC's mission is to be the go-to R&D, Science and Technology (S&T), and Research, Development, Test, and Evaluation (RDT&E) leader within the Homeland Defense and Security community.

HDIAC Overview

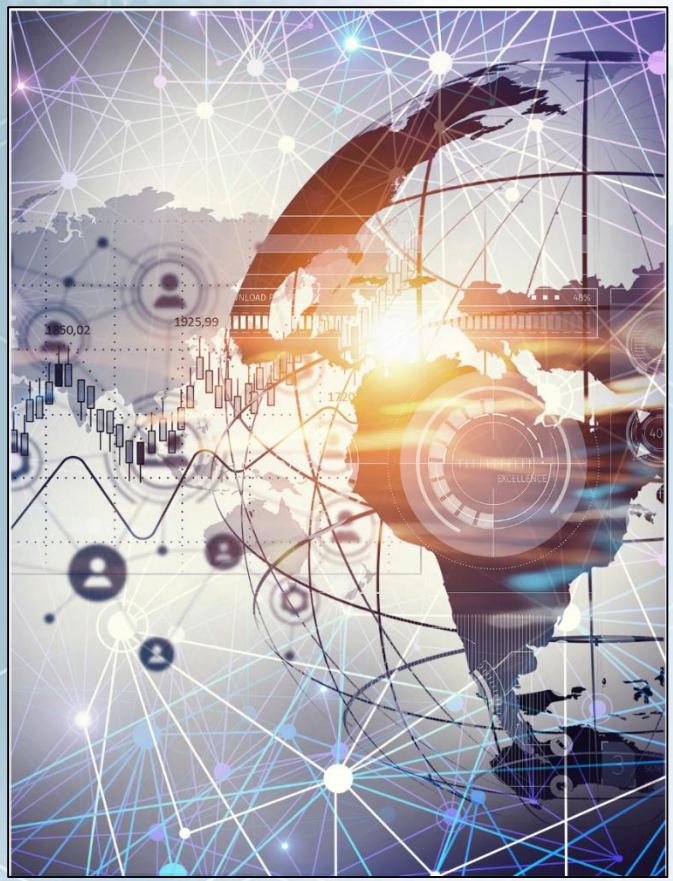
HDIAC Subject Matter Expert (SME) Network

HDIAC SMEs are experts in their field(s), and, typically, have been published in technical journals and publications.

SMEs are involved in a variety of HDIAC activities

- Authoring HDIAC Journal articles
- Answering HDIAC Technical Inquiries
- Engaging in active discussions in the HDIAC community
- Assisting with Core Analysis Tasks
- Presenting webinars

If you are interested in applying to become a SME, please visit HDIAC.org or email info@hdiac.org.



Overview: DoD and the Digital Twin

- Significant advances in computer processing capability, speed, and storage have enabled what DoD terms *digital engineering*
- The digital twin, or a virtual representation of an object, system, or process, was first coined by Dr. Grieves in 2002
- Digital twin technology allows engineers to refine their designs prior to manufacture and closely monitor an asset through its full lifecycle
- Use cases include spaceflight systems, aircraft carriers, energy systems, and entire ports
- As DoD notes in its *Digital Engineering Strategy* (June 2018), this approach will help DoD maintain technological overmatch, and shape the S&T "workforce to innovate, experiment, and work more efficiently."

Presenter

Michael Grieves, E.D.M.

Dr. Michael Grieves splits his time between the business and academic worlds. He is a leading expert worldwide in Product Lifecycle Management (PLM), and lectures widely on engineering, manufacturing, and PLM at both industry and academic conferences. Dr. Grieves has published widely, including several seminal books on PLM, and holds an appointment as Research Professor at the Florida Institute of Technology. He has more than three decades of experience in the computer and data communications industry, is an entrepreneur, and has served as a senior executive at Fortune 1000 firms. Dr. Grieves has a BSCE from Michigan State University and an MBA from Oakland University. He received his doctorate from the Case Western Reserve University Weatherhead School of Management.

Setting the Stage

Product and Systems

Products

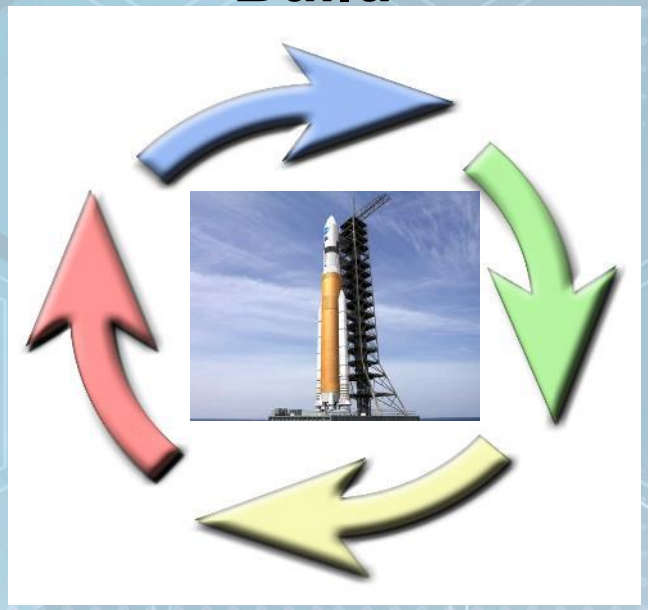
Systems

Products and Systems

Product Lifecycle – 4 Phases

Build

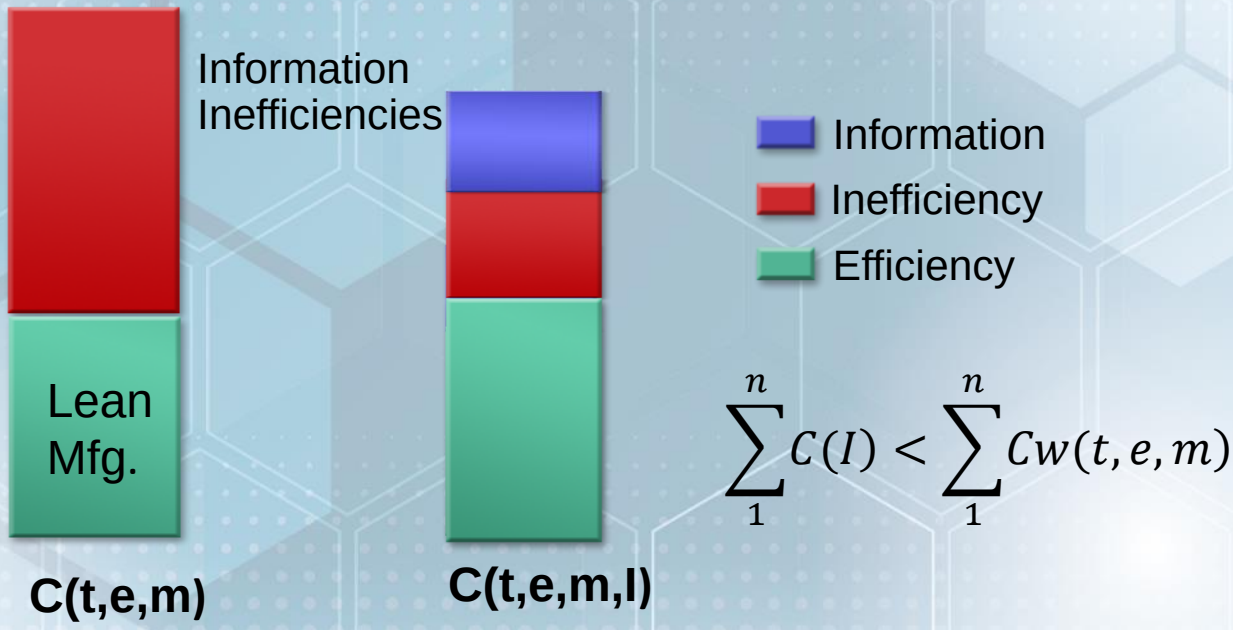
Create



Operate/Sustain

Dispose

Digital Twin Information as Time, Energy, Material Trade-off

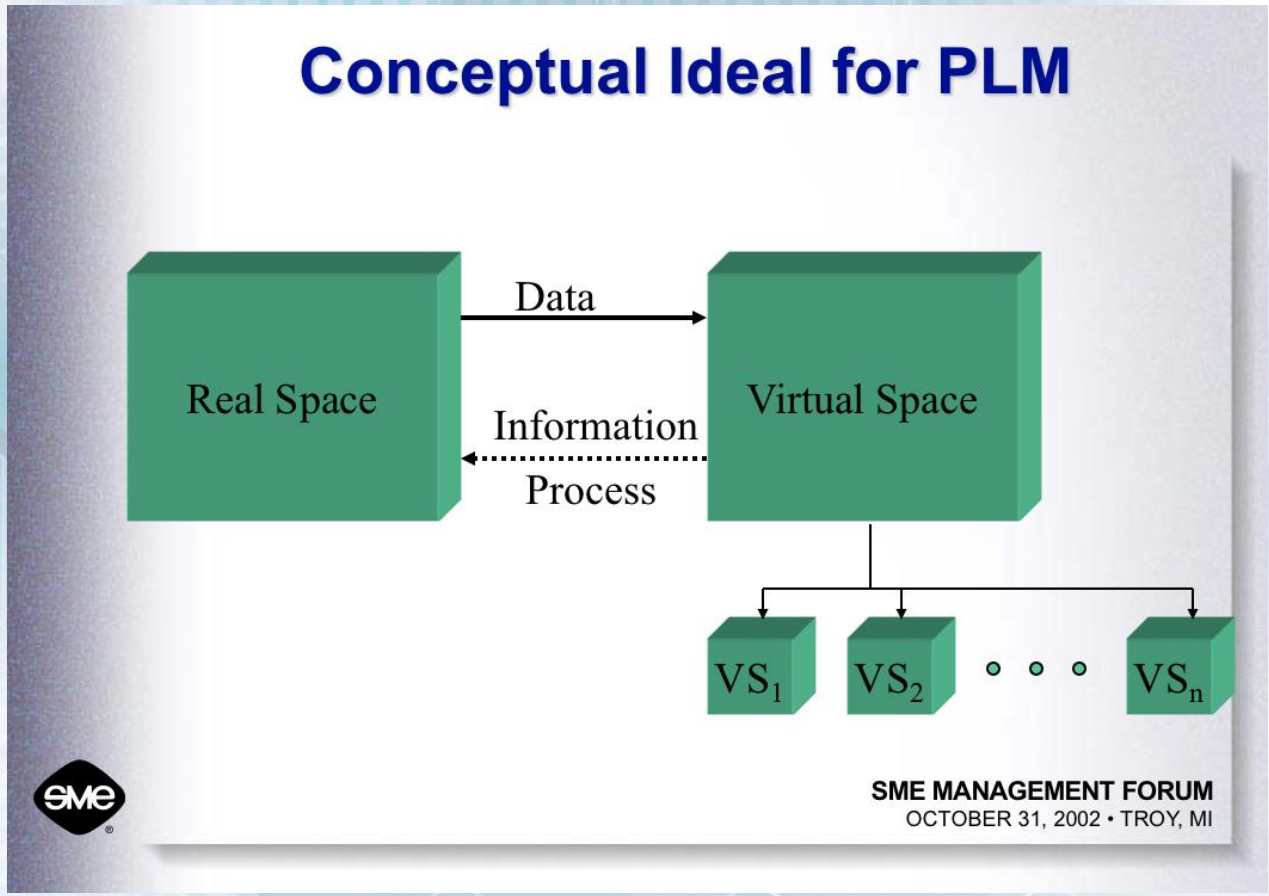


What is the Digital Twin?

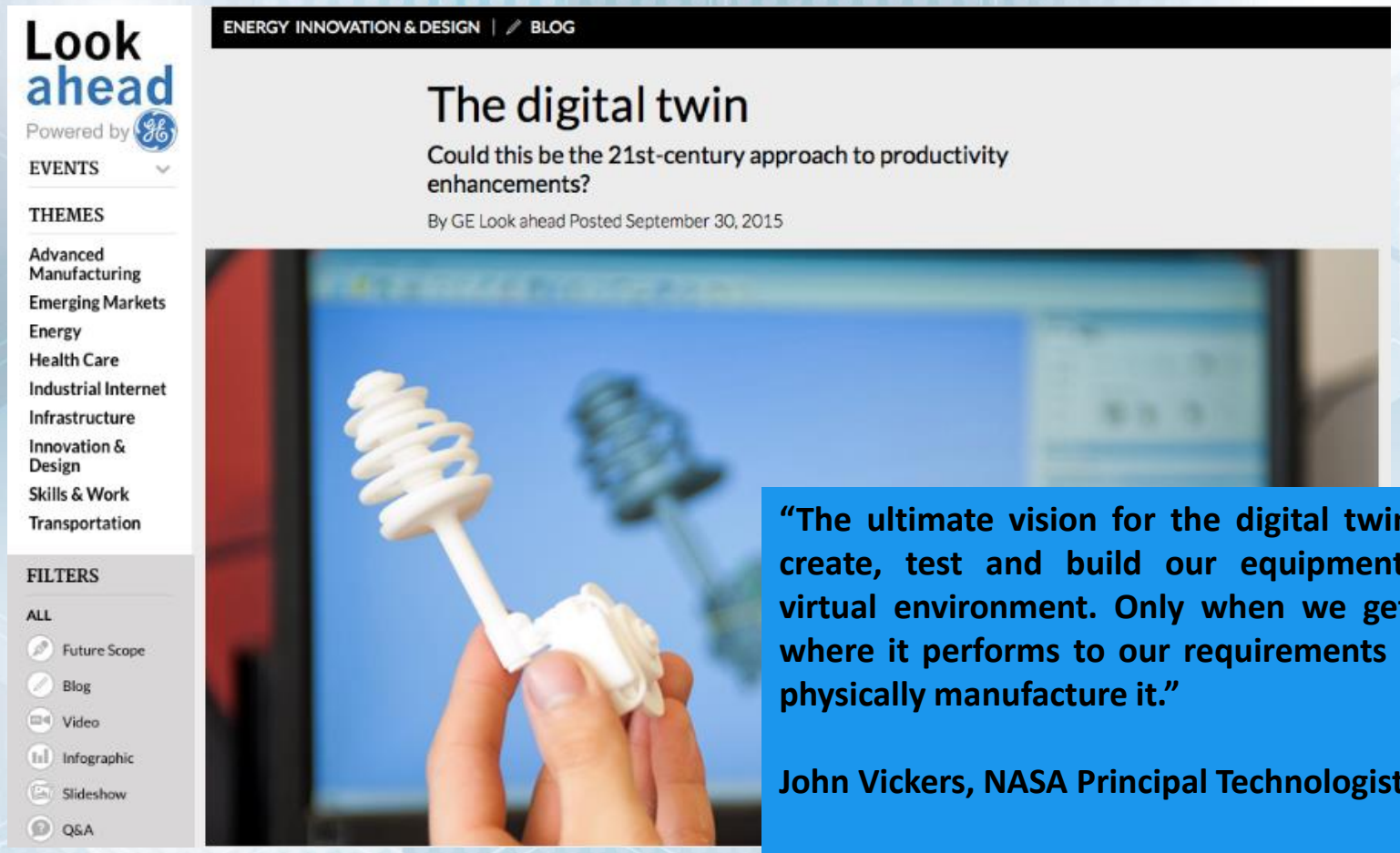
Digital Twin Definition

Digital Twin is a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level. At its optimum, any information that could be obtained from inspecting a physical manufactured product can be obtained from its Digital Twin.

Source: Grieves, M., & Vickers, J. (2016). Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems. In F.-J. Kahlen, S. Flumerfelt, & A. Alves (Eds.), *Trans-Disciplinary Perspectives on System Complexity* (pp. 85-114). Switzerland: Springer.


Conceptual Ideal for PLM
Real Space
Data
Information
Process
Virtual Space
VS1
VS2
VSn
SME MANAGEMENT FORUM
OCTOBER 31, 2002 • TROY, MI

Digital Twin – Rapidly Increasing Interest



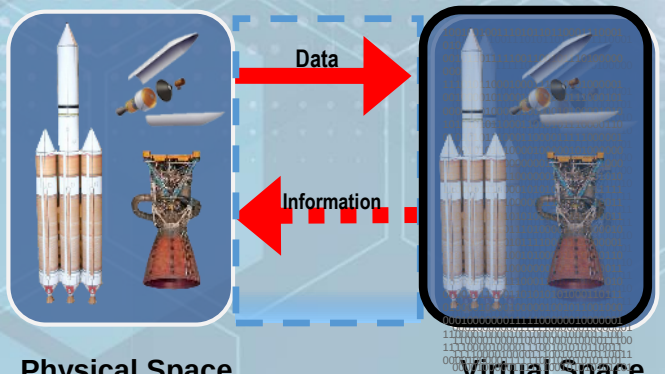
"The ultimate vision for the digital twin is to create, test and build our equipment in a virtual environment. Only when we get it to where it performs to our requirements do we physically manufacture it."

John Vickers, NASA Principal Technologist

And eventually print it!

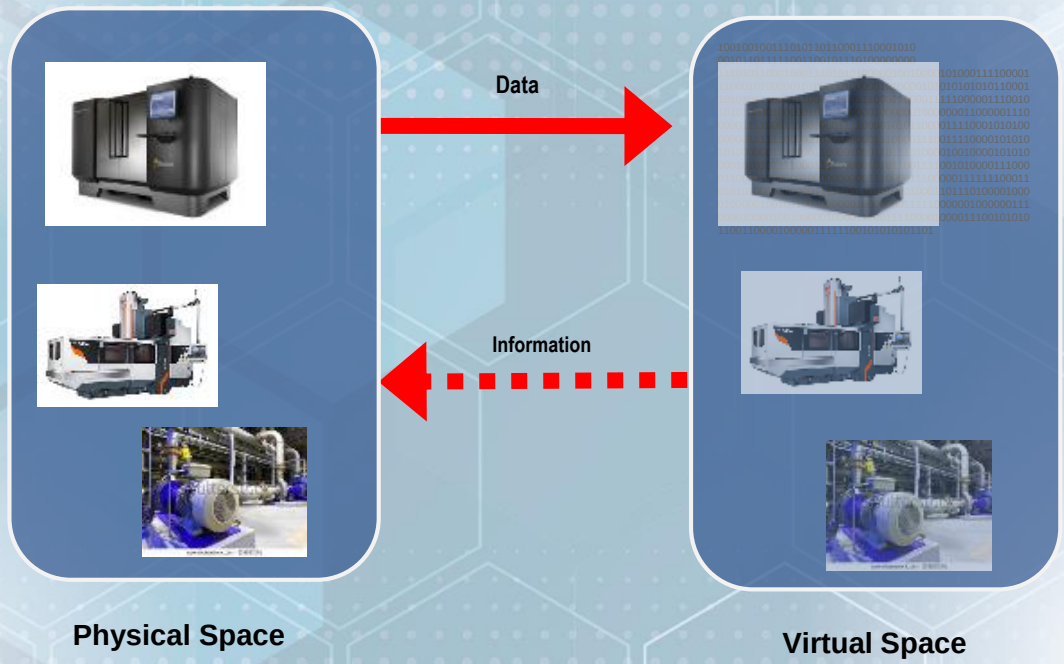
http://gelookahead.economist.com/digital-twin/

Digital Twin Model



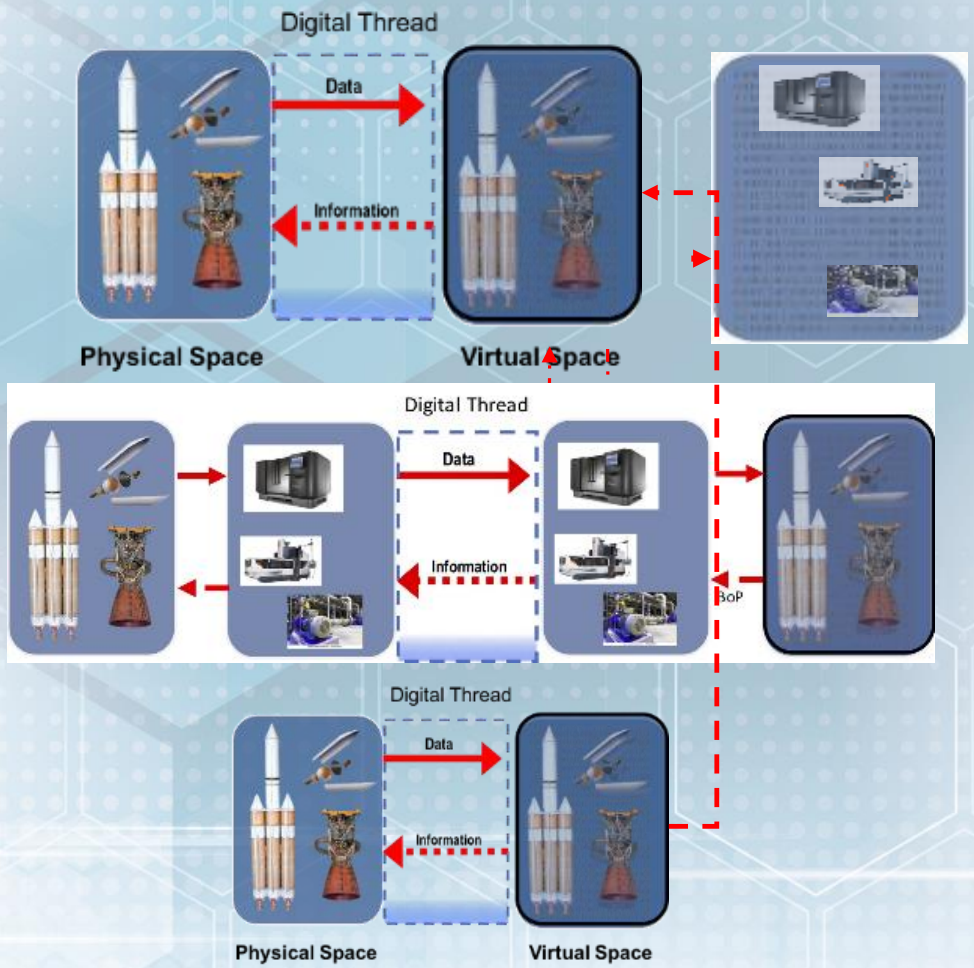
Digital Twin Environment

Digital Twin Model – Factory



Industry 4.0
Smart Manufacturing

Digital Twin Model through Lifecycle



What are the types of Digital Twins?

Digital Twin Types (DT)

Digital Twin Prototype (DTP)

VR

- Digital Twin Instance (DTI)

AR

Interrogative

- Digital Twin Aggregate (DTA)

Prognostics/
Learning

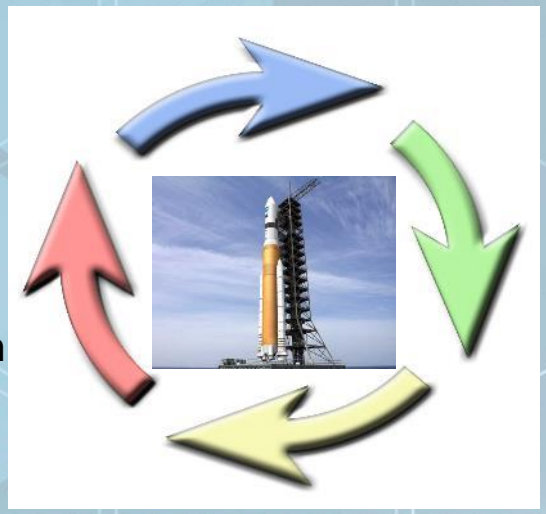
Product Lifecycle – 4 Phases

Digital Twin Instance

Build

Create

Digital Twin Prototype



Operate/Sustain

Digital Twin Instance/Aggregate

Dispose

Interrogative/Predictive/Learning

How much fuel does this tank have? What is its position? How many rounds has it fired?

Air intake inlet is partially clogged and needs cleaning. Engine bearing F61 will fail in next 40 hours.

Based on past tank experience, throttle back X MPH when incline is Y degrees in order to prevent tread slippage.

What is the Physical Twin?

Physical Twin (PT)



Smart

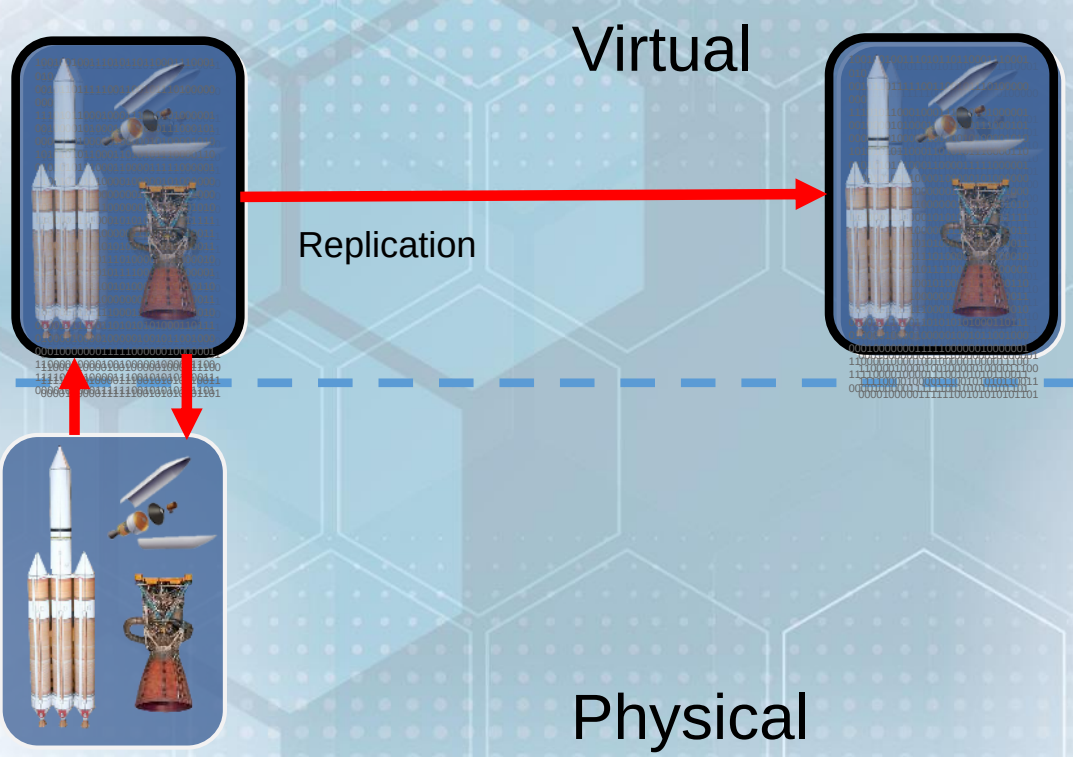
- Sensing
- Translating
- Comparing
- Reacting

Smart, Connected

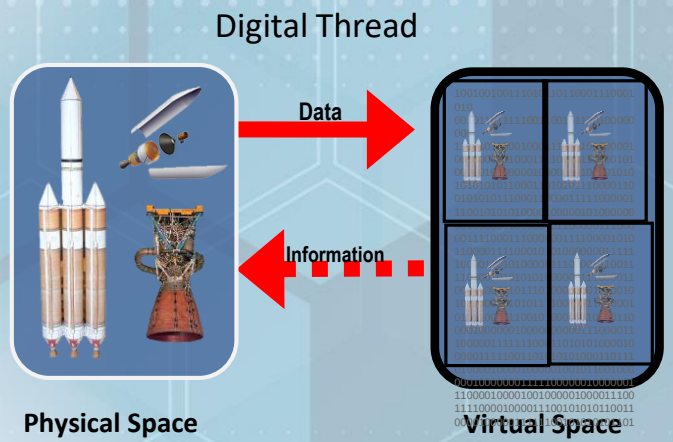
- Communicating, Assessing, Response
- Protecting

Digital Twin Evolution

Digital Twin in Time



Intelligent Digital Twin (IDT) ML/AI

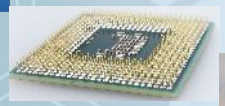


- Capture lessons learned
- Cued Availability
- Sensemaking
- FRS Multi-Scenario
- Decision Support/Making

Digital Twin Concerns

Cyberphysical security

- Macro
- Micro
- Autonomous/ML/AI



Massive data, limited information

Interoperability/harmonization/standardization

Machine to Machine Escapes

Supply chain weak links

Digital Twin Use Cases

Create
- Requirement development and verification
- Model release
- Design review
- Digital mockup unit (DMU)
- Engineering change process
- Component update
- Pre-release collaboration
- Product integration
- Product configuration control and validation
- Behavior and performance analysis
- Procurement
- Marketing material
- Next-generation product
- Part reuse and Where used
- Packaging

Dispose
- Verified Disposal/Regulatory Compliance
- Project Archiving

Build
- Bill of Process Development
- Rapid Prototyping
- Work Instructions
- Cobotics
- Factory Simulation
- Machine Augmentation Quality (Specification)
- Control Supply Nets
- Factory Replication
- Factory Front Running Systems (FRS)

Use/Sustain
- Configuration Management
- Maintenance, Service, and Repair Product
- Behavior/Performance Prognostics
- Product Augmentation
- Product as a Service
- Service as a Product Compliance/Archiving
- Augmented Reality (AR) Repair Front Running Systems (FRS)

Questions?