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Digital Engineering for Strategic Competition:

Accelerating the Defense Capabilities Development and Acquisition Cycle

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OUT OF TIME: China is out-pacing U.S. development of new, advanced weapon systems

China developed and fielded the J-20 to counter the F-22 …

in less than 10 years!

Persistent problems plague U.S. defense weapon systems:

- Siloed requirements generation
- Optimistic TRL
- Poor cost estimations
- Insufficient understanding of sub-components and systems
- Difficulties integrating subsystems
- Difficulties testing technologies
- Ineffective oversight and program management

SecAF Kendall: "I have been sounding alarms about China's military modernization program. There is no time to lose in responding to this challenge."

RISK: "Rapid" Acquisition Offices are insufficient to deliver capabilities *at scale*

Rapid capabilities and innovation offices have been successful at cutting through bureaucracy and accelerating target programs.

but…

These offices have limited impact because they do not address the vast majority of DAF acquisition programs.

And their authorities and span on control are different than normal acquisition offices.

Government Accountability Office: "GAO added DOD's weapon system acquisition process to its High-Risk List in 1990."

To scale and transform, the DAF needs to accelerate capability development and delivery through *normal acquisition*

Implementing digital engineering across the DOD is imperative to win the strategic competition with China

FINDING: Digital Engineering can accelerate the acquisition, development, and fielding of new capabilities – *without acquisition reform*

Digital Engineering can:

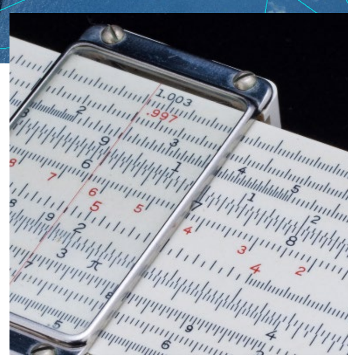
- **Improve requirements analysis and trade-off studies**
- **Reduce engineering rework**
- **Provide for continuous government insight and oversight**
- **Improve production quality**
- **Improve sustainment and modernization efforts**

What is “digital engineering?”

Digital engineering leverages modern IT infrastructure to transform engineering practices and outcomes

First evolution: Systems engineering

1950s - 1970s



Increased complexity of weapon systems demanded a formalized process because:

- Part incompatibilities
- Schedule disconnects
- Budget surprises

Still, the manual paper and slide rules approach to engineering meant design teams could face major problems and disconnects

Systems engineering is a design and management approach that treats the capability as an integrated whole

Computers digitize existing engineering processes

1970s - 1990s

Increased computation and software models empower engineers to advance designs:

- Computer-aided design (CAD)
- Computer-aided modeling (CAM)
- Automated machine tools

Engineering processes remain the same – even as software tools improve, teams still share paper reference materials

Basic engineering process remains unchanged despite advancements in tools from pencils to bytes

Model-based systems engineering make the digitized document primary references

1990s - 2000s

Model-based systems engineering (MBSE) improved program management through enhanced the reliance on digital references:

- Interactive, 3D models
- Digitized simulation and test
- Use with other SW tools

Even though MBSE improved capability development and management, processes still siloed and not comprehensive

Model-based systems engineering began to use digitized tools to enhance program management

Advanced, modern IT infrastructure radically transforms MBSE into "Digital Engineering"

2010s – present

Digital engineering merges MBSE with:

- Big data processing & storage
- Cloud computing
- High-speed, high-bandwidth networks

Digital engineering synchronizes entire program teams to a centralized and authoritative reference repository

Digital engineering enables a seamless "digital thread" to integrate all stakeholders across the lifecycle – *in real time*

Digital Engineering key terms

Authoritative Source of Truth: The centralized and definitive reference point for a program. Contains all system-associated digital models and program data, documentation, and artifacts.

Digital Model: A virtual representation of a complex system.

Digital Twin: An individualized and periodically updated virtual representation of a "specific" real world system. *All* digital twins are digital models. *Not all* digital models have or are digital twins.

Digital Artifact: Models, documentation, and other products (such as performance data or parts numbers) related to a program's development, creation, operation, and sustainment.

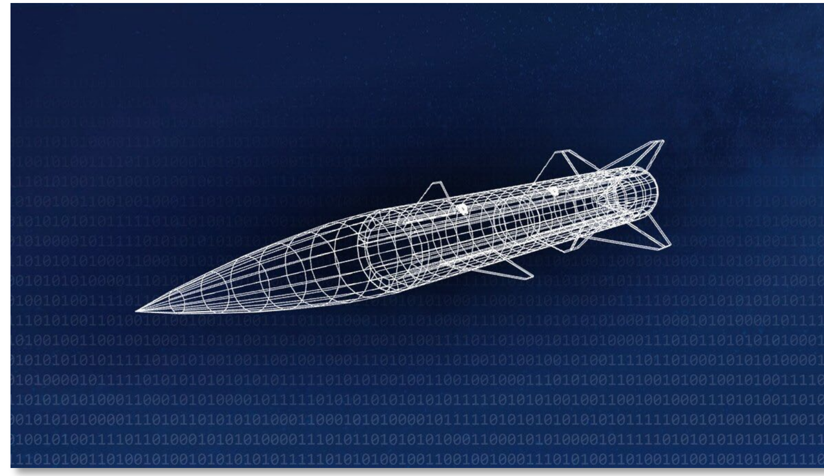
Digital Thread: The IT software and hardware that enables a digital model to be updated with up-to-date digital artifacts so that it can serve as an "authoritative source of truth."

Different program types benefit differently from digital engineering

Legacy	Hybrid	New Start
Definition: Systems designed before the digitized engineering tools became commonly available.	**Definition:** Systems that use *digitized* engineering during design, and have started to incorporate digital engineering practices later in their lifecycle	**Definition:** Systems designed from the outset using digital engineering tools and techniques
Examples: • B-52 • A-10 • B-1B	**Examples:** • F-35 • F-15 EX • F-22	**Examples:** • B-21 • Sentinel • NGAD
Digital Engineering Applications Today: Sustainment, Training, Retrofit Design	**Digital Engineering Applications Today:** Manufacture, System Optimization	**Digital Engineering Applications Today:** Requirements Creation, Design

Digital engineering can improve speed, cost, and quality across the entire lifecycle of a capability

- Better requirements generation
- Inform tradeoff analysis
- Continuous government oversight
- Accelerated test programs
- Reduced schedules and cost
- Enhanced producibility
- Improved production planning, manufacturing efficiencies and quality
- Improved maintenance and readiness



- Expanded quality training options for maintenance and operations
- Support planned capability upgrades and service life extension programs

DE can accelerate the development, acquisition, and fielding of new capabilities – *without acquisition reform*

Digital engineering can also enhance the sustainment and modernization of legacy systems

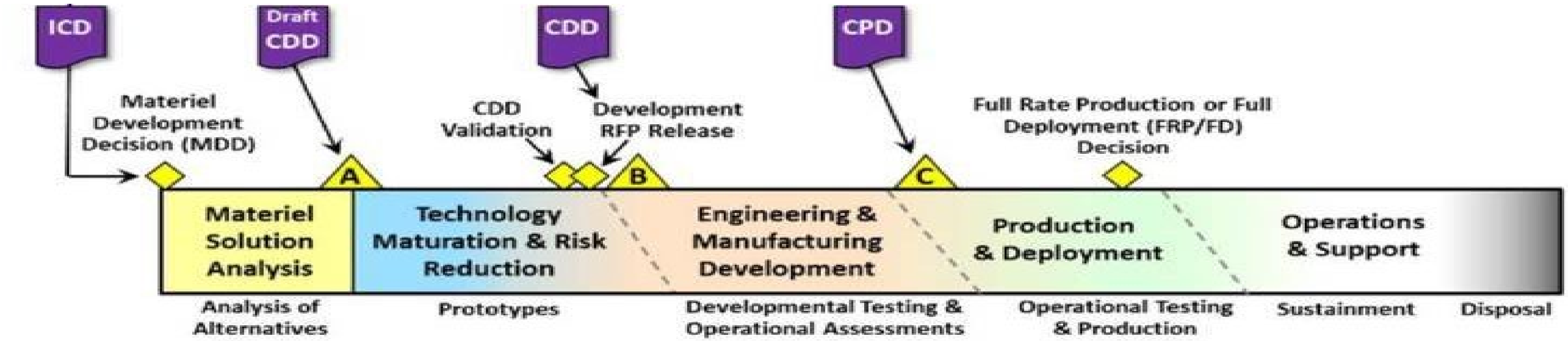
- **Address diminishing manufacturing sourced parts**
- **Improve spares strategies and parts upgrades**
- **Expand the supplier base**
- **Accelerate and support capability insertion programs**
- **Support major component replacement**
- **Support service life extension programs**

Supporting legacy and hybrid systems requires “reverse digital engineering” and can be time consuming and expensive

DAF must be discerning when deciding how to scope the application of DE to legacy and hybrid weapon systems

CHALLENGE: Digital engineering faces barriers to adoption within the DAF

- **Reconstructing DE artifacts will require significant engineering efforts or have substantial technical debt.**
- **The costs & financial benefits of implementing DE are not well understood.**
- **Lack of digital tools, tool incompatibility, or immaturity can hinder adoption.**
- ***CULTURAL RESISTANCE* and *LACK OF EXPERTISE* of DAF workforce.**



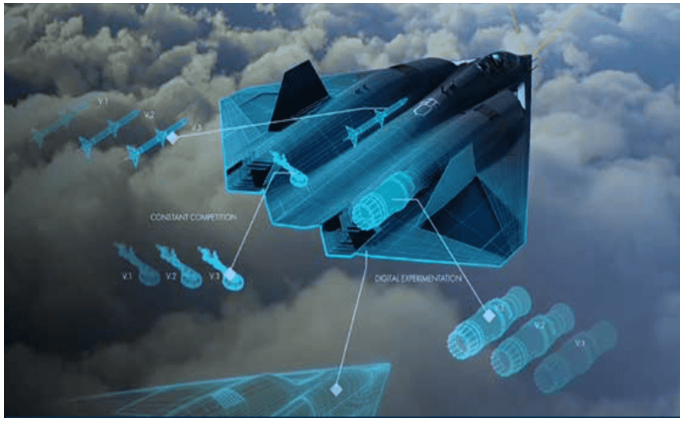
The DAF must overcome these barriers if it is to realize the benefits of DE

Recommendations

1. **DAF leadership should incentivize the use of comprehensive digital engineering for new start acquisition programs.** Rewarding digital engineering for new start acquisition programs to maximize the design and testing efficiencies and enable long-term affordable sustainment.

2. **DAF acquisition leaders should assess the feasibility of digital engineering solutions for legacy and hybrid weapon systems.** Acquisition leaders should evaluate where targeted digital upgrades can offer significant advantages before mandating the use of digital engineering for hybrid and legacy platform retrofits or sustainment actions.

3. **DAF leadership must train its acquisition workforce to use digital tools and processes.** Developing federal and service workforce expertise and buy-in for using digital engineering is foundational to fully access its benefits and mitigate its costs.



U.S. Air Force

Recommendations

4. **DAF acquisition leaders must promote open standards for digital engineering tools.** While companies may derive unique benefits from developing their own tools, DAF leaders should mandate the use of open standards or interfaces that ensure a variety of vendor tools, software, and formats are interoperable.

5. **The DAF should maintain a library of digital engineering tools accessible to small businesses, sub-tier suppliers, or other non-traditional companies.** This could help these smaller entities to standardize their digital products and activities, improve the quality of their product, and ultimately expand the larger digital ecosystem.

6. **The DAF and its prime contractors, partners, and suppliers must ensure their IT infrastructures are modernized and secure.** Every participant in DAF programs must have an IT infrastructure with sufficient capacity, speed, and security to function effectively in the digital ecosystem.

Digital engineering can restore the speed of capability development, acquisition, and fielding needed to outpace China

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