CREATE^{TM}-AV Program and NAVAIR System Engineering Transformation Vision for Acquisition and Support Programs

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Presented to:

Presented by:
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NAVAIR

Outline and Points to Ponder

- **What is CREATE's purpose?**

- **How has CREATE impacted our developmental and fielded systems**

- **How will CREATE-AV impact future systems**

- **How will CREATE-AV impact future procurement activities**
  - *Systems Engineering Transformation*

- **Program Implementation Progress**

What Is CREATE's Purpose?

- *"to improve DoD Acquisition Processes for Aircraft, Ships, and RF Antennas "*

- *A software development program to produce Production Quality, Maintainable, Ship, Aircraft, and Antenna Design and Analysis software for the relevant acquisition engineering workforce – CREATE is in its 10th year!*

- *CREATE has relationships with Air Force, Army, and Navy research labs and engineering organizations to produce needed science and technology breakthroughs for software products to realize full potential on next generation compute platforms.*

CREATE's Purpose is real and it is being realized through acquisition programs and for in-service support!

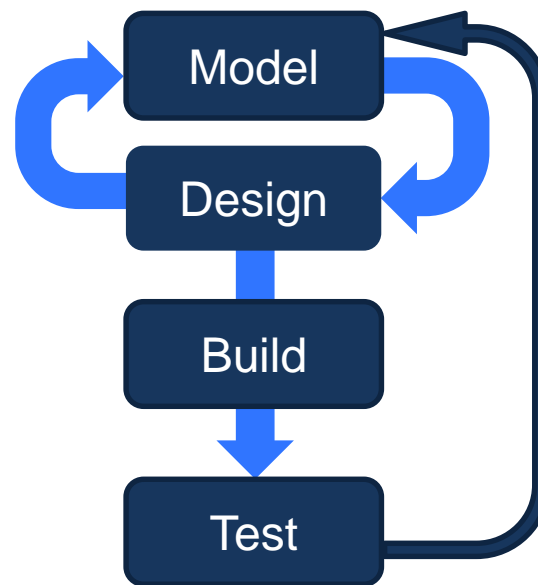# Engineering Paradigm Shift Enabled

Time ~20-30 yrs

Design

Build

Test

Cost $$$$$

Empirical Basis

~5-7 yrs

Model

Design

Build

Test

$$$

Computational Basis

Participants in the Paradigm

Shrink the time from CD to FRP and make processes from Milestone-C through Sustainment much more efficient

Concept Refinement | Technology Development | System Development & Demo | Production & Deployment | Operations and Support

A — B — C

LRIP | FRP | Sustainment

CD | DRR | FRP DR

Air Vehicle Program Offices – e.g., PEO JSF, PMA-265 (F/A-18), etc.

- Conceptual Design Orgs of the Services
- Research Organizations of the Services

- Research & Engineering Organizations of the Services

- Engineering and T&E Organizations of the Services

Government Owned Processes

Industry Owned Processes

Government Owned Processes

Pratt & Whitney — A United Technologies Company

Bell Helicopter — A Textron Company

BOEING

NORTHROP GRUMMAN

Rolls-Royce

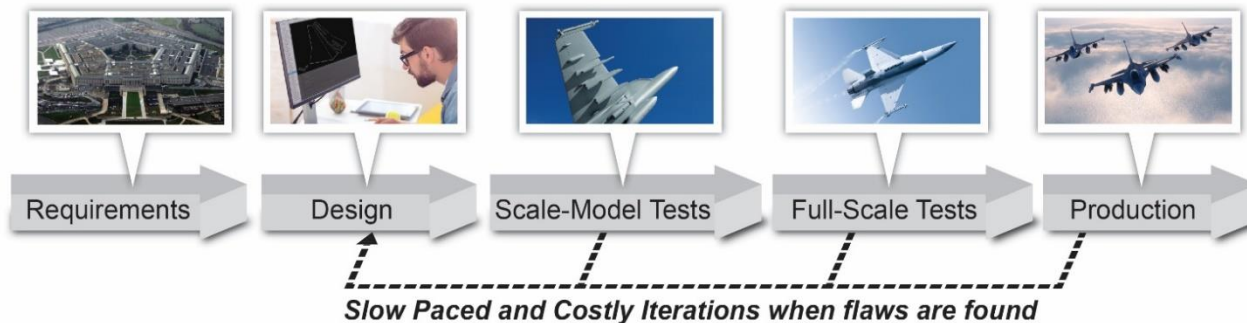Sikorsky — A United Technologies Company

Raytheon

LOCKHEED MARTIN

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Innovation with Computational Prototyping and HPC

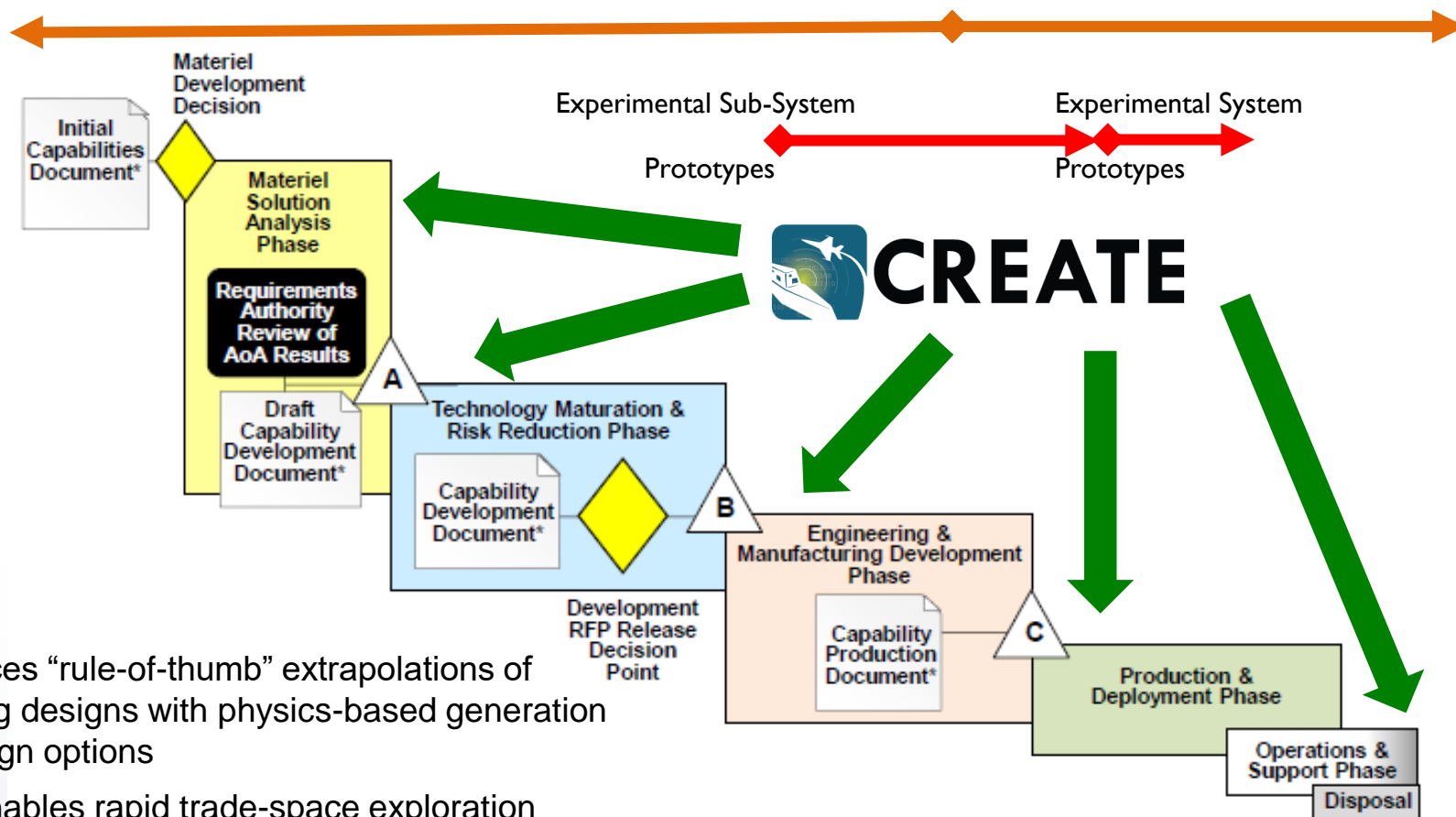Try, Fail, and Fix Early and Often, Before You Cut Metal!

Exisitng DoD Paradigm

Requirements → Design → Scale-Model Tests → Full-Scale Tests → Production

Slow Paced and Costly Iterations when flaws are found

HPC CREATE Procecss

CREATE

Requirements → Design & Optimize Virtual Products → Analyze & Test Virtual Products → Build & Test Physical Product → Deploy and Sustain

Fast and Cost-effective Design Iterations

Accurate High Speed Physics Calculations

DOD HPC MODERNIZATION PROGRAM

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Physics-based Computing Tests of Computational Prototypes—Moves "Testing to the Left (and Right)"

Experimental Sub-System Prototypes

Experimental System Prototypes

CREATE

Materiel Development Decision

Initial Capabilities Document*

Materiel Solution Analysis Phase

Requirements Authority Review of AoA Results

A

Draft Capability Development Document*

Technology Maturation & Risk Reduction Phase

Capability Development Document*

B

Development RFP Release Decision Point

Engineering & Manufacturing Development Phase

Capability Production Document*

C

Production & Deployment Phase

Operations & Support Phase

Disposal

- Replaces "rule-of-thumb" extrapolations of existing designs with physics-based generation of design options
  – Enables rapid trade-space exploration
  – Provides physics-based analysis tools to assess the feasibility of the design options
- CREATE augments "failure data from live tests" with "predictions of computational prototype performance," providing timely decision data that identifies design flaws and performance shortfalls early, allowing them to be fixed before metal is cut

CREATE: Enabler of Digital Engineering

1. ## Formalize development, integration and use of models
   - CREATE Develops and Deploys 11 Physics-based HPC tools being used by over 180 DoD engineering organizations to design, analyze, and predict the performance of over 70 weapon systems instantiated in a digital model of each weapon platform

2. ## Provide an enduring authoritative source of truth
   - The laws of physics applied to digital models of weapon platforms with potential to aggregate all the important information produced during acquisition process

3. ## Incorporate technological innovation
   - CREATE Tools include all the important physics, address full-size systems, utilize accurate algorithms, and are extensively verified and validated with DoD T&E data

4. ## Establish supporting infrastructure and environments
   - High Performance Computing Modernization Program Eco-system (High Performance Computers, Secure high-speed networks, CREATE tools, T&E data for V&V,… for DoD engineers)

5. ## Transform a culture and workforce
   - Enables paradigm transition from iterated "design, build, test,…" to iterated "model, design,…" followed by build and test. Builds organic workforce and enables it to "own" design process, take risks, and identify and fix design defects before metal has been cut.

Installed User Base

- **CREATE – AV Active Licenses ~ 700+**

  - *Tri-Services*
    - *NAVAIR, NAVSEA, AFLCMC, AFRL, AFLCMC, AFSEO, AFIT, AEDC, Edwards, Holloman AFB, Hill AFB, ARMDEC, AFDD, ARL*
  - *ERS*
  - *NASA*
  - *USNA*
  - *USAFA*
  - *Universities:*
    - *BYU /UCal Davis / Georgia Tech / Penn State / Tenn U/ UMD*
  - *Boeing*
  - *Sikorsky*
  - *Bell*
  - *Northrop Grumman*
  - *Lockheed Martin (Fort Worth / Orlando)*
  - *Raytheon*
  - *Small Companies:*
    - *Clear Science Corporation / General Atomics / Dynetics/ Bihrle Applied Research*

Example: CREATE RF—4 to 5 Training Sessions per year

GTRI: Atlanta

Raytheon, NGC, GA, SPAWAR: San Diego

AFRL, SI2, L3, Leidos, ONI, RRI: Dayton

NASIC, MDA, MSIC, AMRDEC: Dayton

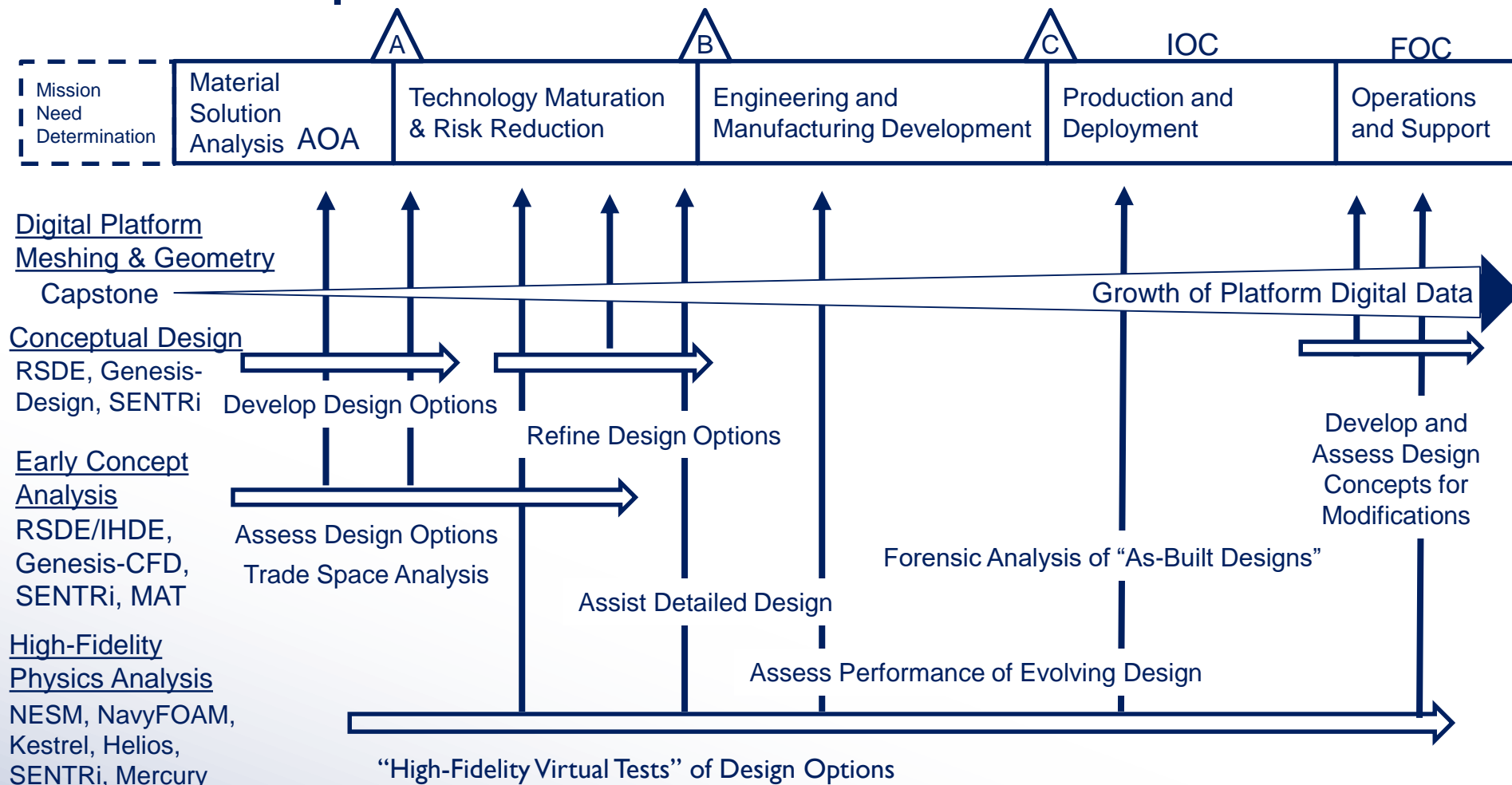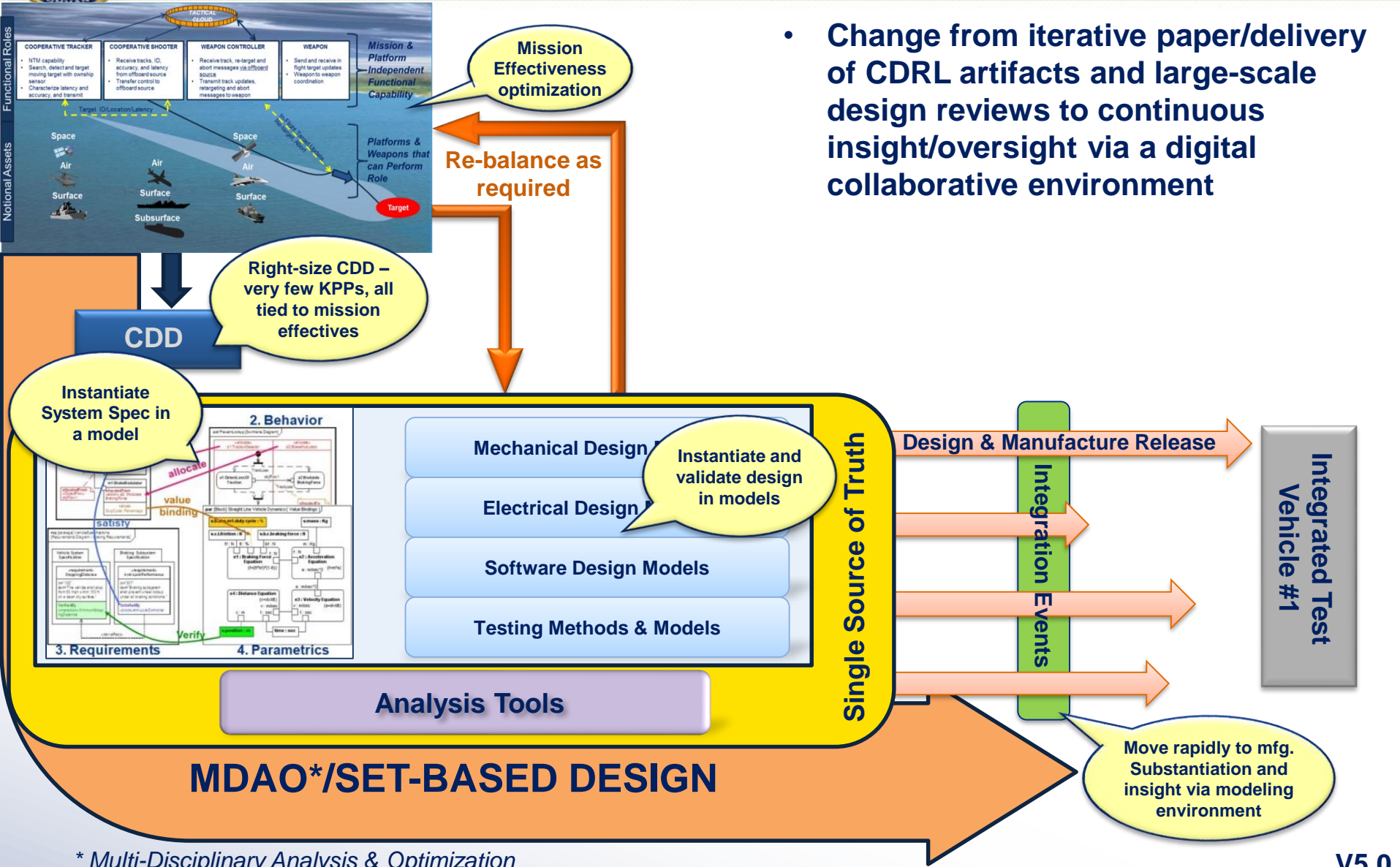MITRE, NGC, AFRL, NASA, Boeing: Dayton

CREATE Designed to Enable Digital Engineering

CREATE Addresses <u>All</u> Phases of Acquisition

Experimental Sub-System Prototypes

Experimental System Prototypes

	A	B	C	IOC	FOC
Mission Need Determination	Material Solution Analysis AOA	Technology Maturation & Risk Reduction	Engineering and Manufacturing Development	Production and Deployment	Operations and Support

Digital Platform Meshing & Geometry
Capstone

Growth of Platform Digital Data

Conceptual Design
RSDE, Genesis-Design, SENTRi

Develop Design Options

Refine Design Options

Develop and Assess Design Concepts for Modifications

Early Concept Analysis
RSDE/IHDE, Genesis-CFD, SENTRi, MAT

Assess Design Options
Trade Space Analysis

Forensic Analysis of "As-Built Designs"

Assist Detailed Design

High-Fidelity Physics Analysis
NESM, NavyFOAM, Kestrel, Helios, SENTRi, Mercury

Assess Performance of Evolving Design

"High-Fidelity Virtual Tests" of Design Options

Systems Engineering Transformation (SET) Framework

- **Change from iterative paper/delivery of CDRL artifacts and large-scale design reviews to continuous insight/oversight via a digital collaborative environment**

Mission Effectiveness optimization

Re-balance as required

Right-size CDD – very few KPPs, all tied to mission effectives

CDD

Instantiate System Spec in a model

Instantiate and validate design in models

Mechanical Design

Electrical Design

Software Design Models

Testing Methods & Models

Analysis Tools

Single Source of Truth

Integration Events

Design & Manufacture Release

Integrated Test Vehicle #1

Move rapidly to mfg. Substantiation and insight via modeling environment

MDAO*/SET-BASED DESIGN

Multi-Disciplinary Analysis & Optimization

V5.0

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A modeling capability, not just a tool…
A Combination of Methodology, Language, and Tools…

Integrated Modelling Environment

Skilled people

Tool-set

Infrastructure

Support
(training and facilities)

Capability Needs

Knowledge management

Capability analysis

Design Methods

MDAO

Systems Engineering

Requirements elicitation
Requirements justification
Requirements analysis
Requirements traceability
Risk management
Configuration Management

Reference Model

Process Model

System Model

1. Structure   2. Behavior
3. Requirements   4. Parametrics

Mechanical Design Models

Electrical Design Models

Software Design Models

Testing Methods & Models

Generic Knowledge Model

Libraries

Scripts

<Script>

Document map and template

Enterprise Interfaces

Acquisition Docs:
System
Specifications
Documentation and
other reports

(DocGen)

(Enterprise)

Business Process

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CREATE Tools Impact Many DoD Programs

NAVSEA

DDG-1000

CVN-78 Class

Columbia SSBN
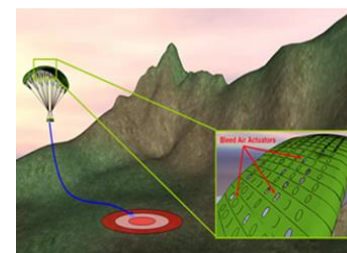

LX(R)

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Aerostar & Raven UAVs
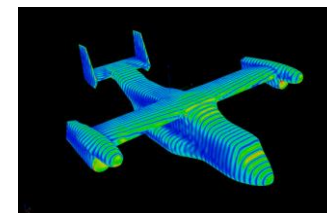

F/A-18 E/F/G

E-2D

ARMY/USMC

UH-60
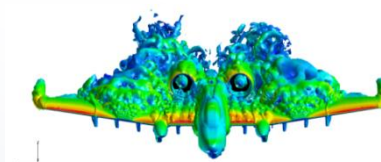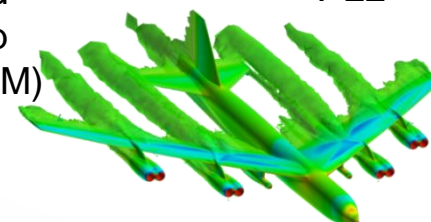

CH-47 (ACRB)

Guided Airdrop (RDECOM)

V-22

AFLCMC

F-15 SA/DB-110
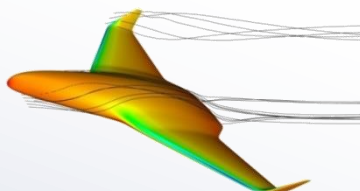
Strategic Airlift CP&A

A-10

B-52

NAVAIR

Kestrel Usage

A-10

T-53A

F-35 Inlet

AFLCMC

AEDC

Facilities

F-35 Bay

AFRL/RQH,X,MN

Army-Natick/USAFA

C-130 Wake

AFSEO

NAVSEA

NASA

SLS

NAVAIR (4.3.2.1)

P-8A

E-2D

F-22/F-16/F-35

Impulse response

F-35B

F/A-18 E

NAV AIR

Kestrel Usage

"We have a few customers that were not happy about CFD being included on their test. After the test however, they were so impressed with results, they came asking if they could pay for us to do more." -- AEDC

Summary

- CREATE tools are making a difference in how we do our jobs, support of programs, and provide capability to the fleet in aviation, maritime, ground, and electromagnetic warfare domains.

- Model-based acquisition/Systems Enginering Transformation/Digital Thread can increase how much we use M&S for DoD programs

- Tremendous progress has been made by the CREATE team and investment strategy of the HPCMO

- Enables the DoD to accelerate acquisition

- Government-developed, government-owned, and government-supported data and products to meet DoD needs

- Adoption expanding across DoD government, industry, and academic enterprises

- Major enabler of the OSD Digital Engineering, the Air Force Digital Thread/Digital Twin, and the Engineered Resilient Systems Programs

- Excellent growth potential to meet needs for many future DoD warfare domains

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