Accelerating Defense Innovation with Computational Prototypes and Supercomputers

NDIA 20th Annual Systems Engineering Conference
October 23-26, 2017, Springfield, VA

Dr. Douglass Post, HCPMP CREATE Associate Director

DOD HPC MODERNIZATION PROGRAM

HPCMP Ecosystem

DOD HPC MODERNIZATION PROGRAM

Users

DOD HPC

A technology-led, innovation-focused program committed to extending HPC to address the DoD's most significant challenges

DoD Supercomputing Resource Centers (DSRCs)

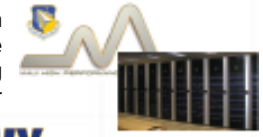
(DSRCs)

U.S. Air Force Research Laboratory DSRC

U.S. Army Research Laboratory DSRC

U.S. Army Engineer Research and Development Center DSRC

Maui High Performance Computing Center



U.S. Navy DSRC

Networking and Security

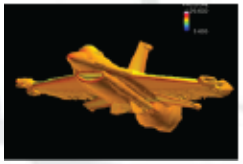
Defense Research & Engineering Network (DREN)

Computer Network Defense, Security R&D, and Security Integration

Software Applications

Core Software

Computational Environments

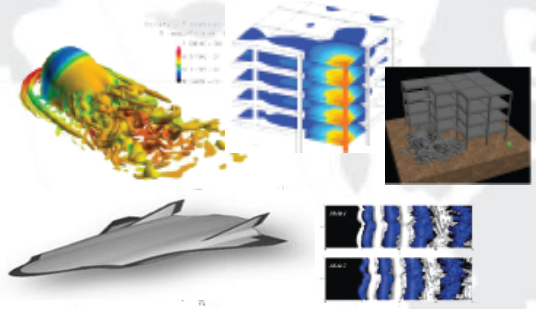


Education and Training

HPC User Support

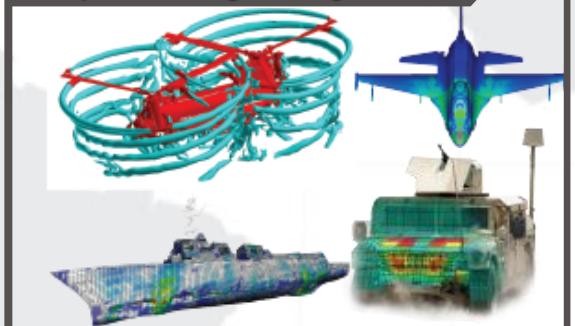
Results

Science and Technology



Test and Evaluation

Acquisition Engineering



Who May Run on HPCMP Resources?

- DoD Employees and Contractors (Researchers and Engineers)
- University Staff with a DoD Research Grant

Interested?

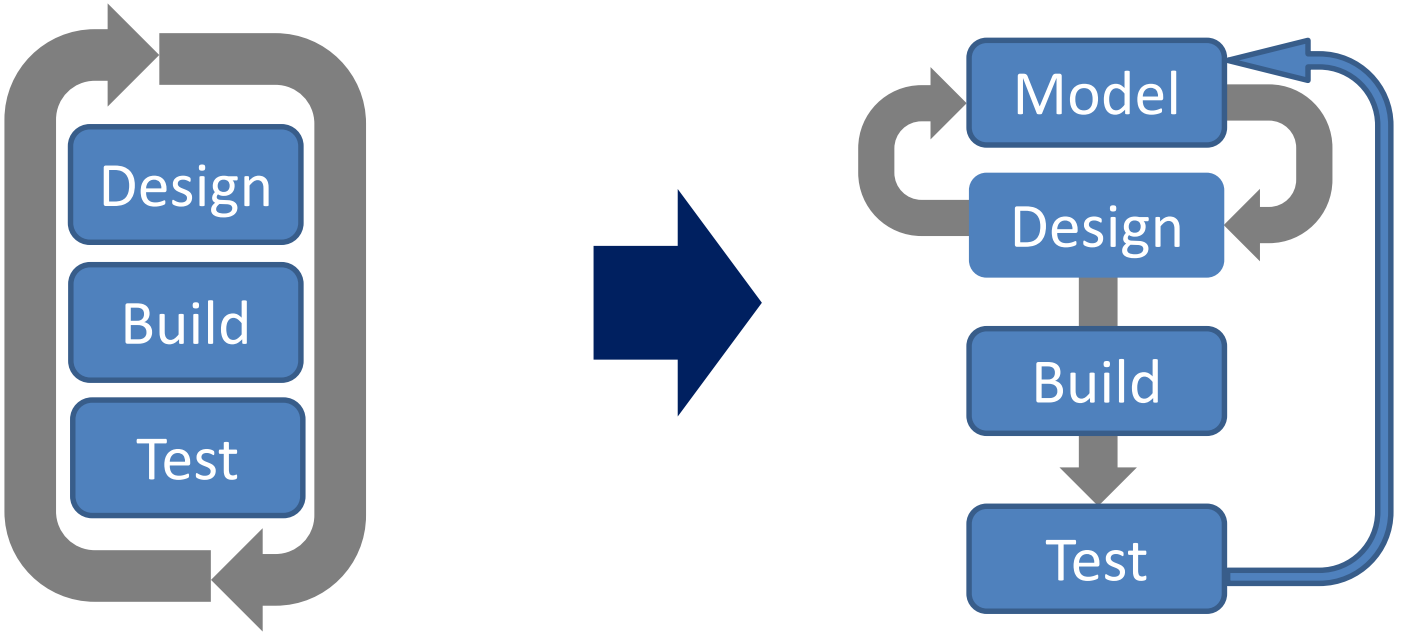
- Contact your Service (Army, Navy, Air Force, OSD, DARPA, MDA, DTRA,…) representative
- Information available at www.hpc.mil under the "For Users" menu with the Topic: "Who May Run on HPCMP Resources"
- Send an email to REQUIRE@hpc.mil to find your Service Representative

See the CREATE Exhibit in the Lobby

A Paradigm Shift Enabled by 60 Years of Progress in Computing

Time ~20-30 yrs

~5-7 yrs



Cost $$$$$

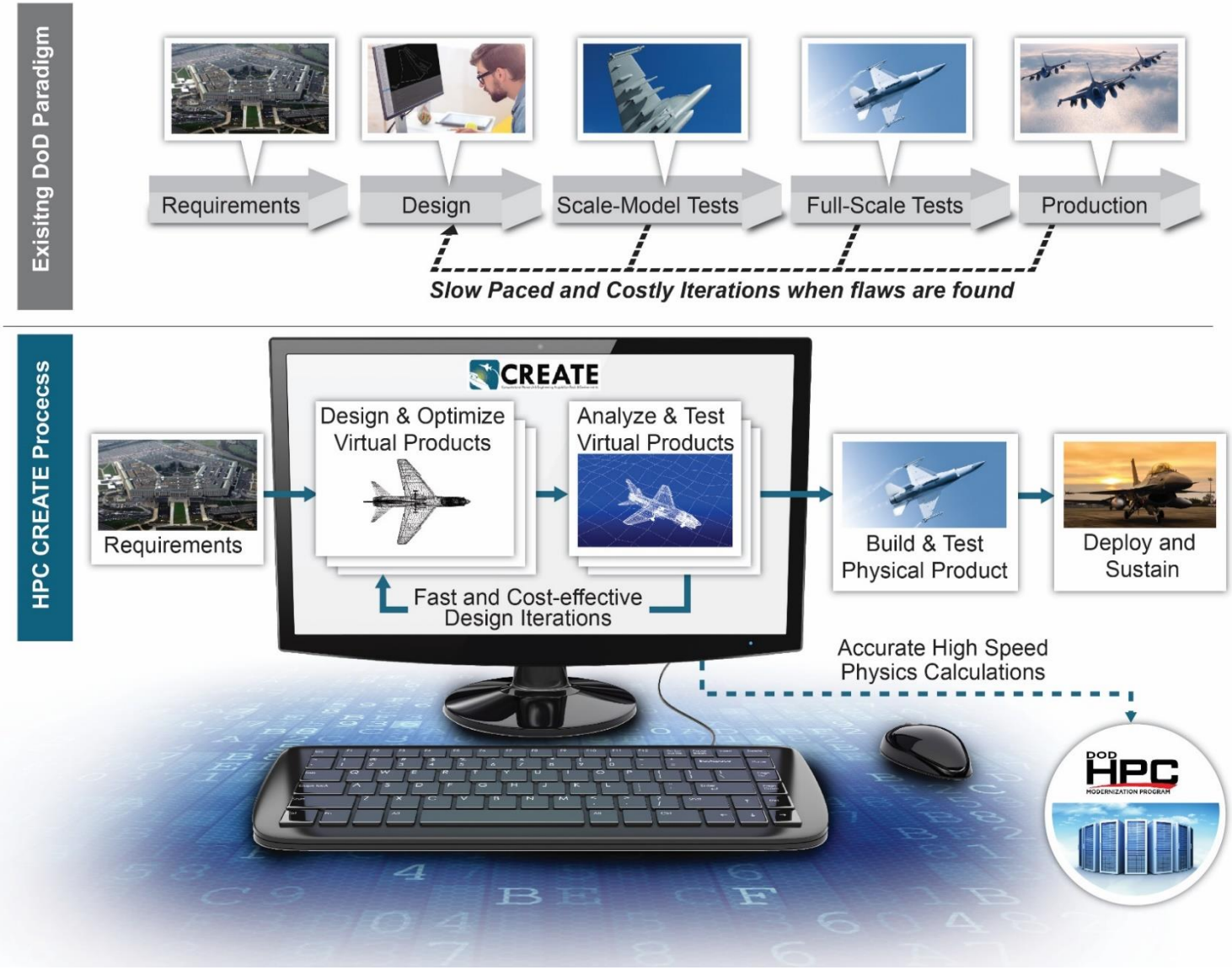
$$$

Empirical Basis

Computational Basis

Innovation with Computational Prototyping and HPC

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



CREATE 5 Projects: 11 Multi-Physics Software Tools

- **Air Vehicles—CREATE-AV**
  - Genesis - Rapid conceptual design for academic use
  - Kestrel - High-fidelity, full-vehicle, multi-physics analysis tool for fixed-wing aircraft
  - Helios - High-fidelity, full-vehicle, multi-physics analysis tool for rotary-wing aircraft
- **Ships—CREATE-Ships**
  - Rapid Ship Design Environment (RSDE) - Rapid Design and Synthesis Capability
  - Navy Enhanced Sierra Mechanics (NESM) - Ship Shock & Shock Damage Assessment
  - NAVYFOAM - Ship Hydrodynamics — predicts hydrodynamic performance
  - Integrated Hydro Design Environment (IHDE) - Facilitates access to naval design tools
- **RF Antenna—CREATE-RF**
  - SENTRi- Electromagnetics antenna design integrated with platforms
- **Ground Vehicles—CREATE-GV**
  - Mercury – High-fidelity, multi-physics simulation tool for vehicle systems and components
  - Mobility Analysis Tool (MAT) – Analysis tool to evaluate ground vehicle performance metrics
- **Meshing and Geometry—CREATE-MG**
  - Capstone - Components for generating geometries and meshes needed for analysis
- **HPC Portal—Secure access to computers through a browser**

CREATE-AV
Aircraft (AV) Design Tools

CREATE-SHIPS
Ship Design Tools

CREATE-RF
Radio Frequency (RF) Antenna Design and Integration Tools

CREATE-GV
Ground Vehicle Design Tools

CREATE-MG
Meshing and Geometry (MG) Support

180+ user orgs
- 50% industry
- 40% government
- 10% other

- >1600 licenses
- 70+ programs

CREATE reduces risk, increases decision space, and supports accelerated production schedules

CREATE is 11 separate partnerships with 11 individual DoD Service Engineering Organizations

HPCMP Director

CREATE Program Associate Director

Official HPCMP Advisory Panel

Ships Project
Project Manager
HPCMP Lorton

NavyFOAM
NSWC, Carderock

Integrated Hydro Design Environment
NSWC, Carderock

Navy Enhanced Sierra Mechanics
NSWC, Carderock

Rapid Ship Design Environment
NSWC, Carderock

Air Vehicles Project
Project Manager
HPCMP, Lorton

Kestrel
46th Test Wing, Eglin AFB

Quality Assurance
NAVAIR, Patuxent River

Helios
Army AFDD, Ames

Genesis Design
HPCMP, WPAFB

RF Antennas Project
Sensors Directorate, AFRL, WPAFB

SENTRi
Sensors Directorate, AFRL, WPAFB

Meshing & Geometry Project
Capstone
Project Manager
Navy NRL

Ground Vehicles Project
Project Manager

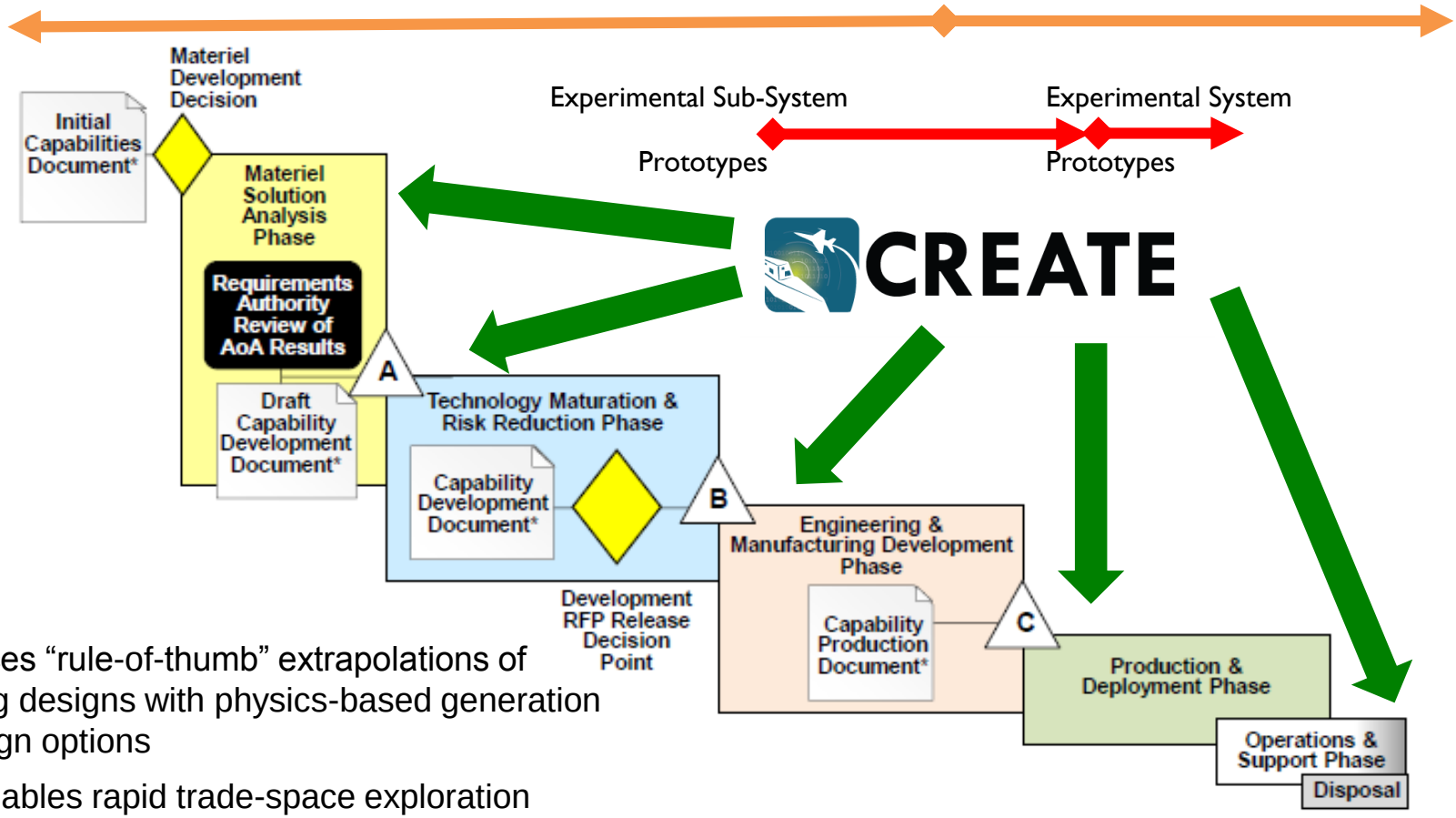
Mercury
ERDC

MAT
TARDEC

A Multi-Institutional, Multi-Organizational, Distributed Program

CREATE: Agility for the Acquisition Cycle

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



- 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.

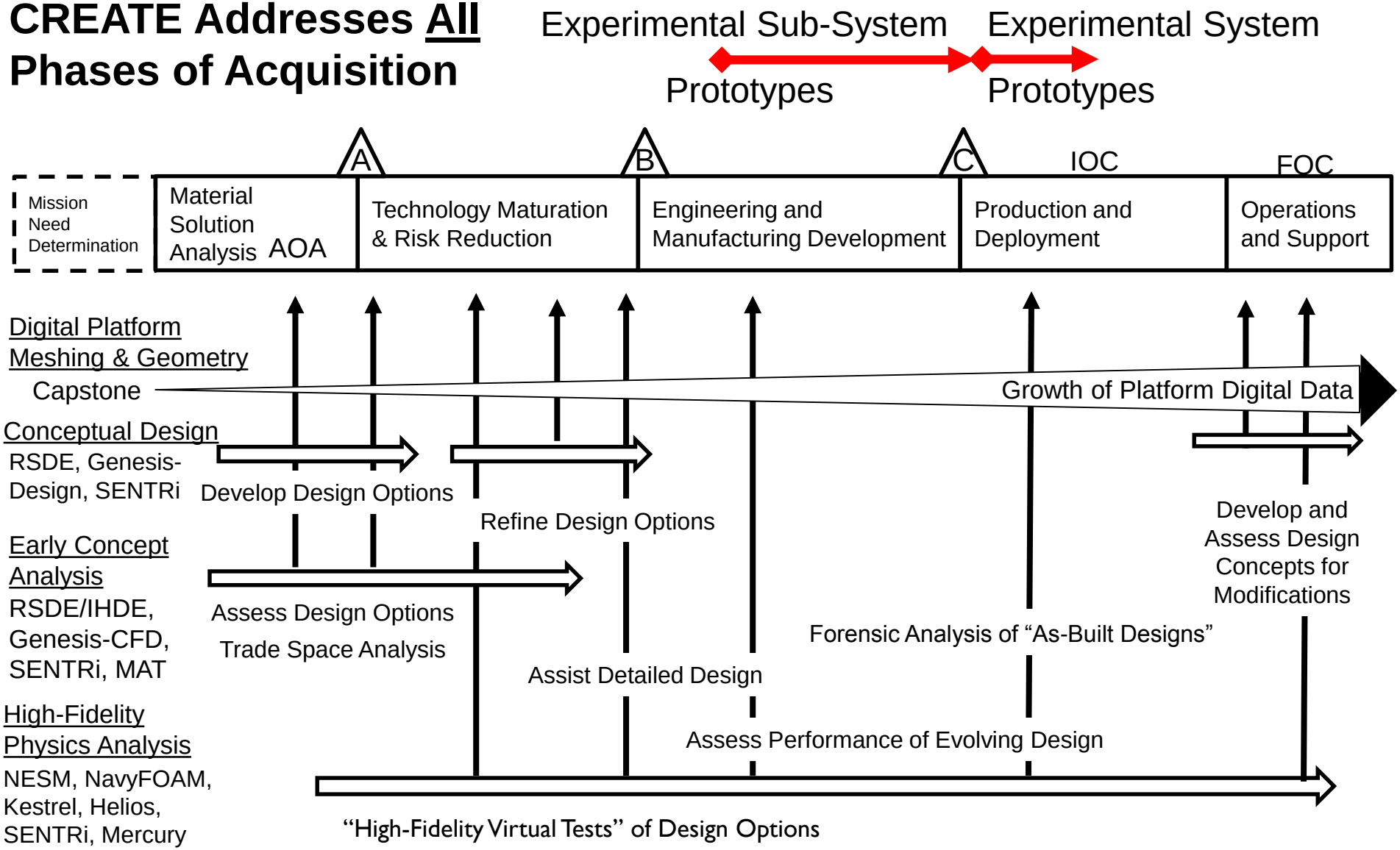
CREATE Grows and Trains DoD Organic Workforce

Getting the tools into the hands of design engineers

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

CREATE Designed to Enable Digital Engineering

CREATE Addresses All Phases of Acquisition



CREATE Tools Impact Many DoD Programs

DOD HPC MODERNIZATION PROGRAM

NAVSEA

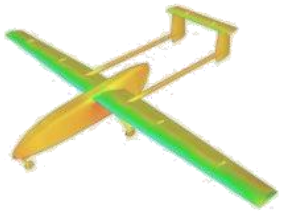
DDG-1000

CVN-78 Class

Columbia SSBN

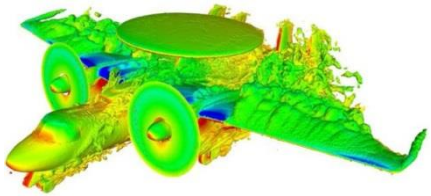
LX(R)

NAVAIR



Aerostar & Raven UAVs

F/A-18 E/F/G

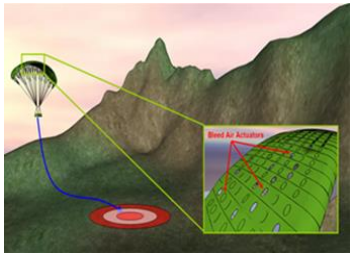


E-2D

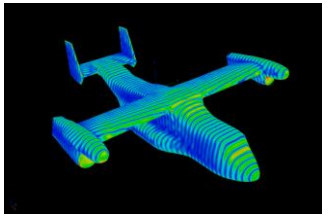
ARMY/USMC

UH-60

CH-47 (ACRB)



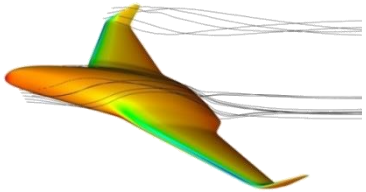
Guided Airdrop (RDECOM)



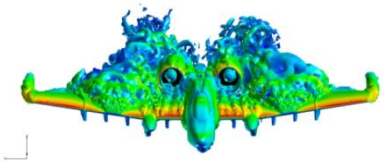
V-22

AFLCMC

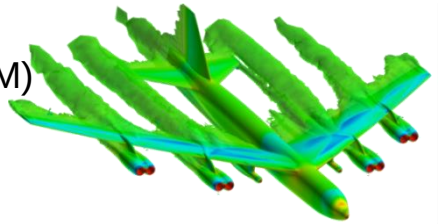
F-15 SA/DB-110



Strategic Airlift CP&A



A-10



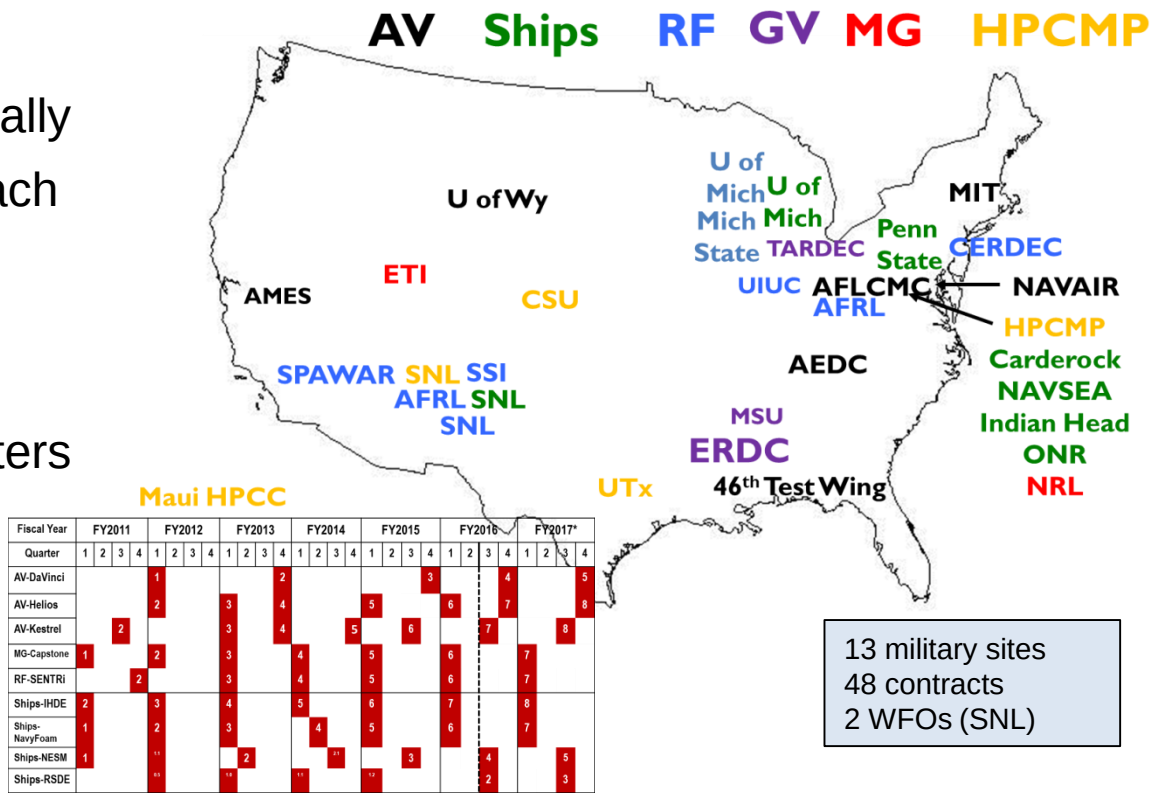
B-52

Build the Right Software, and Build it Right!

- **Software built by government-led teams of 5 to 10 staff**
  - **Technical team and team leader embedded in customer organizations**
  - **Optimal balance of team agility, structured process, and accountability**
- **Highly Disciplined Software Development Processes**
  - **Strong emphasis on software quality and accountability**
  - **Supportive code development environment—virtual clusters, central servers and code repository, high performance computers**

Annual releases

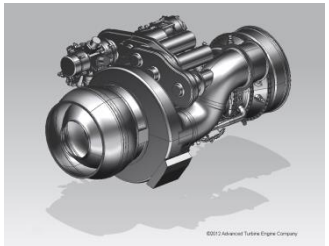
- Increased capability annually
- Extensive beta-tests of each release
- Rigorous V&V process
- Improved scalability for massively parallel computers
- Improved usability
- Responsive to evolving requirements
- Extensive documentation



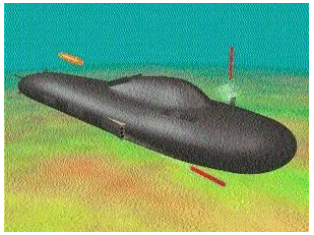
13 military sites
48 contracts
2 WFOs (SNL)

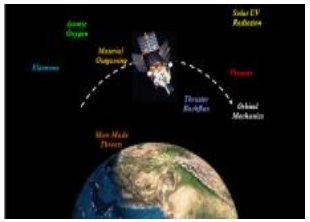
CREATE—Looking to the Future

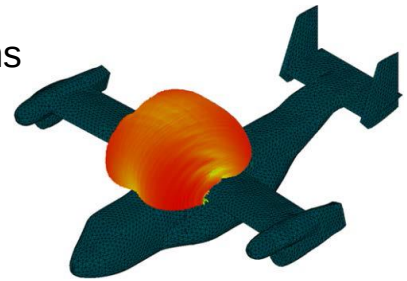
Areas for near-term impact:



- **Hypersonics**: Investments are impacting current and future timeframes (CREATE- AV Kestrel potential)
- **New Submarine Development**: Planning and design work underway (CREATE-Ships RSDE) with ERS help
- **Vertical Heavy Lift (JMR-TD)**: Critical capability for the future for both manned and unmanned systems. Needed for future force structure planning and operational execution. (CREATE-AV Helios has been used for the down-select from 4 to 2 concepts)
- **Space Technology**: critical design space exploration impacting all Services (e.g., satellites, weapons, sensors, etc.)
- **Improved Turbine Engine Program (ITEP)**: CREATE-AV Kestrel & Helios in use for analysis of engine integration
- **EW/Radar/Antenna Modeling**: S-Band, X-Band, Phased Array design analysis electronic warfare opportunities
- **Directed Energy**: Analysis of EM and aerodynamic systems being investigated by Kestrel and SENTRi
- **Service Life Prediction**: Contributes to sustainment of existing DoD systems through advanced mechanics







CREATE Take Aways

- CREATE: Physics-based computational engineering tools to meet DoD needs in aviation, maritime, ground, and electromagnetic warfare domains
  - Government-developed, government-owned, and government-supported 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

CREATE Leadership Team Contacts

DoD High Performance Computing Modernization Program (www.hpc.mil)

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