



CREATE Computational Modeling Support for the Engineered Resilient Systems Program and Computational Prototyping Environment

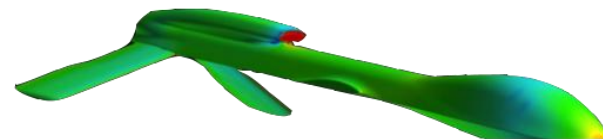
**NDIA Systems Engineering Conference
27 Oct 2016, Springfield, VA**

ERS and CREATE



Engineered Resilient Systems

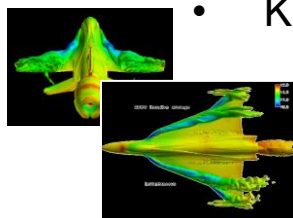
- Architectural Integration
- Tradespace Analysis
- Environmental Simulation
- Big Data Analytics
- Knowledge Management



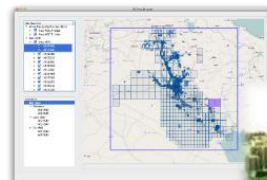
Computational Prototyping Environment

- Generic Workflow Automation
- High-Fidelity Physics Tightly in the Tradespace Loop
- Surrogate Model Development
- 3D Physics-Informed, Gaming-Based Visualization
- Virtual Proving Ground for T&E

CREATE*



- High-Performance Computing
- High-Fidelity Computational Physics
- AV, Ships, GV, RF, MG
- Future possibilities in Space and Electronic Warfare



***DoD HPCMP Computational Research and Engineering Acquisition Tools and Environments**

Computational Research and Engineering Acquisition Tools and Environments (CREATE)

CREATE is a multi-phase program to develop and deploy computational engineering tool sets for acquisition engineers



CREATE
Computational Research and Engineering Acquisition Tools and Environments

- **Aircraft (AV) Design Tools:** Fixed-wing aircraft, rotorcraft, conceptual design, analysis and operational testing and transition
- **Ship Design Tools:** Shock/damage, hydrodynamics, early-stage design & analysis, and operational testing and transition
- **Radio Frequency (RF) Antenna Design and Integration Tools:** Conceptual design and detailed analysis tools relevant to virtually all DOD platforms
- **Ground Vehicles (GV) Tools:** End-to-end mobility solver, provides rapid, physics-based data for design and analysis
- **Meshing and Geometry (MG) Support:** Improves the ease, speed, flexibility, and quality of geometry and mesh generation, and enables the generation of CAD-neutral digital representations and product models of weapons systems & platforms and operational terrains and environments

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



CREATE 6 Projects: 11 Multi-Physics Software Tools

- **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

- **Air Vehicles—CREATE-AV**

- DaVinci - Rapid conceptual design
- 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

- **RF Antenna—CREATE-RF**

- SENTRI - Electromagnetics antenna design integrated with platforms

- **Ground Vehicles—CREATE-GV**

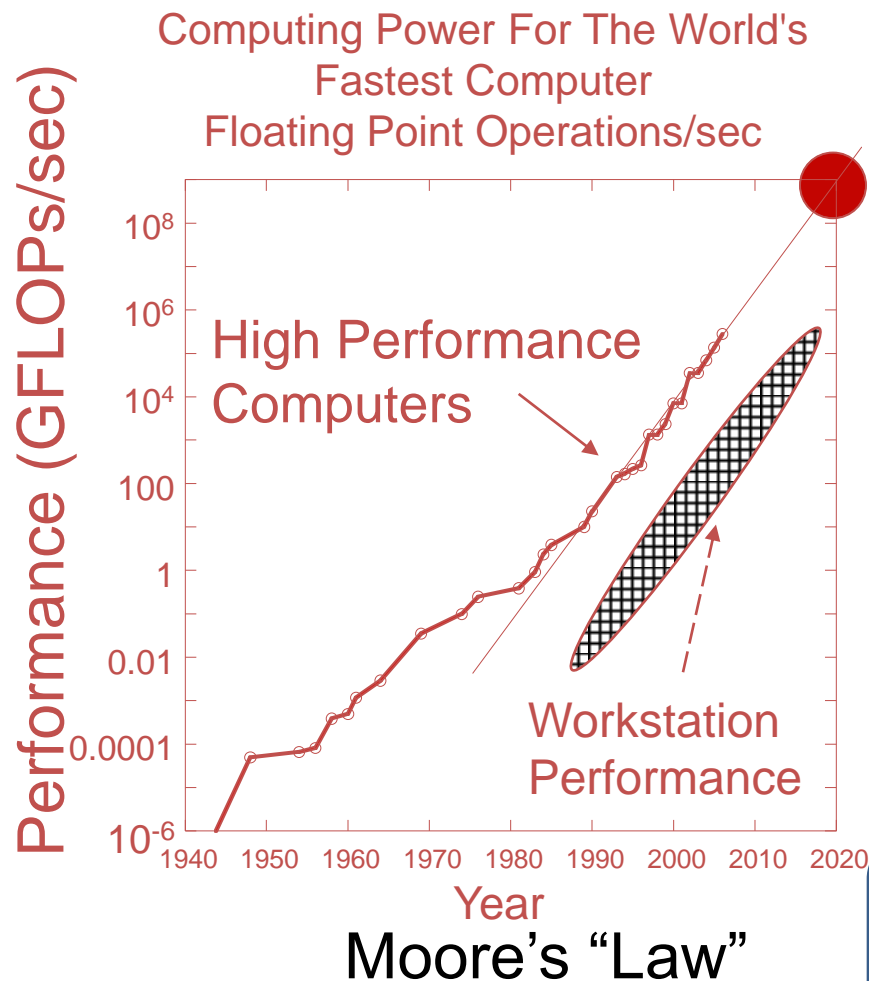
- Mercury – High-fidelity, multi-physics simulation tool for vehicle systems and components
- Mobility Analysis Tool (MAT) – Analysis tool to evaluate ground vehicle performance metrics

- **Meshing and Geometry—CREATE-MG**

- Capstone - Components for generating geometries and meshes needed for analysis

- **HPC Portal—Secure access to computers through a browser**

Enabling Technology: High Performance Computers



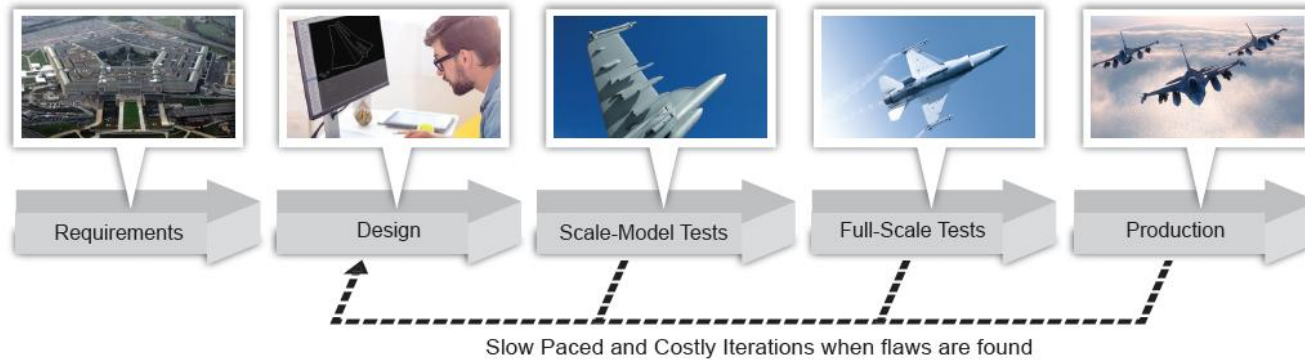
Cores

- The 10^{15-18} increase in computer power over the last seven decades enables codes to:
 - Include all the effects we know to be important—multi-physics
 - Utilize accurate solution methods with extensive VV&UQ
 - Model a complete system
 - Complete parameter surveys in hours, rather than days to weeks to months
- In ~ 10 years, workstations will be as powerful as today's high-performance computers

TODAY Physics-based HPC applications can accurately predict the performance of DoD weapon systems

A New Acquisition Paradigm: Computational Prototyping

Existing DoD Paradigm

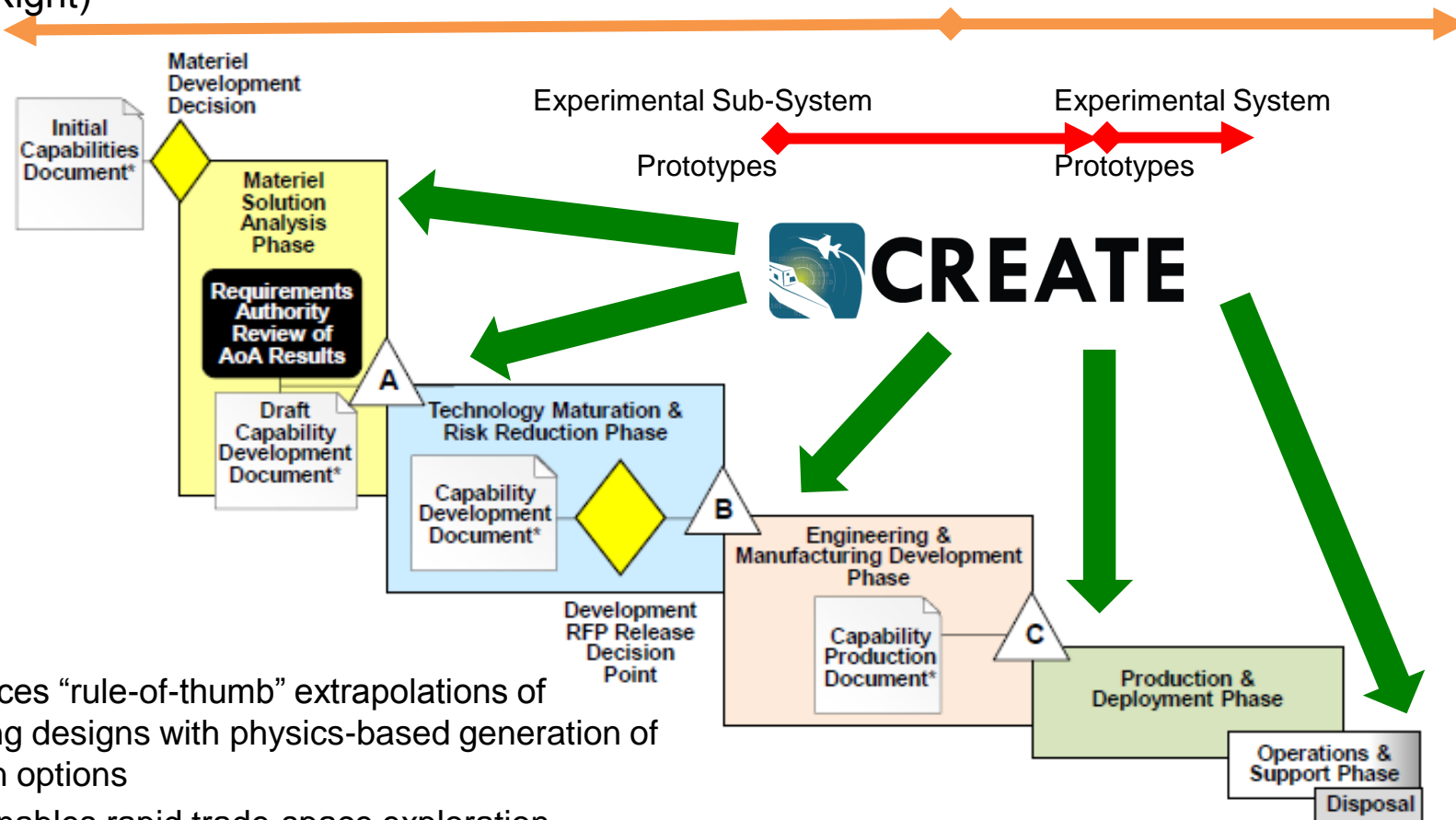


HPC CREATE Process



CREATE: Agility for the Acquisition Cycle

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



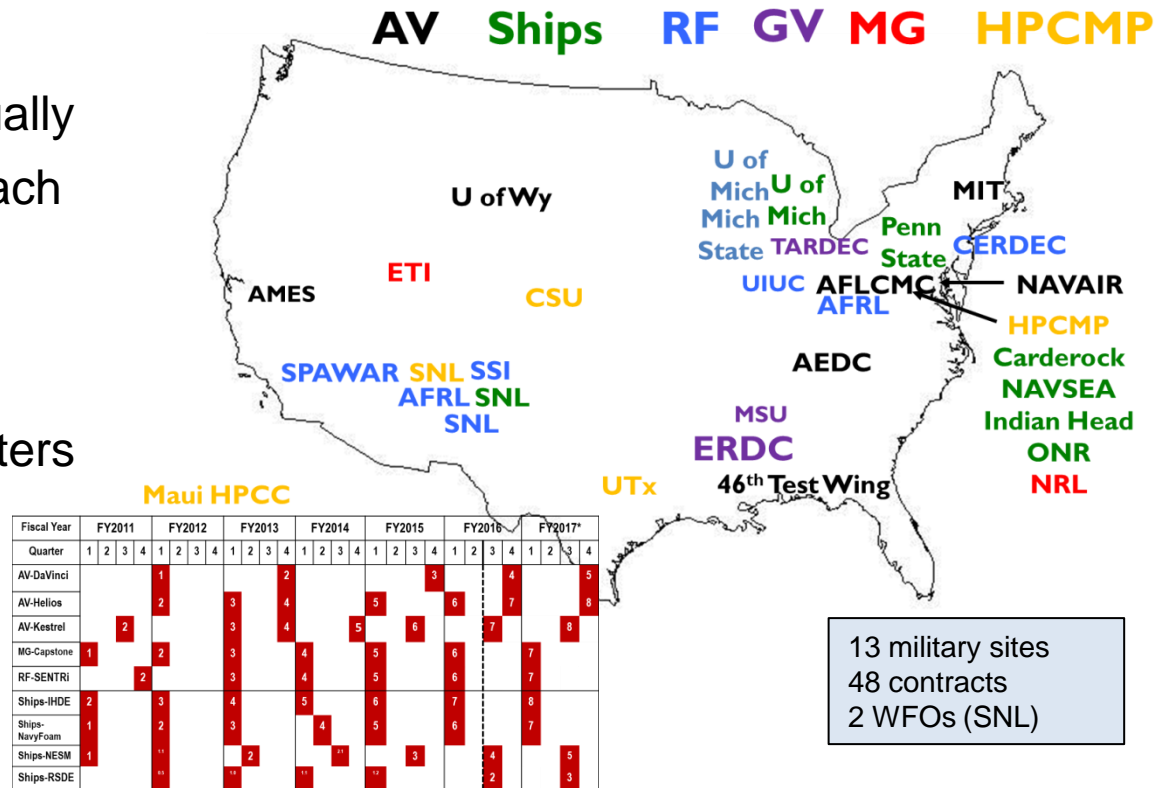
- Replaces “rule-of-thumb” extrapolations of existing designs with physics-based generation of design options
 - Enables rapid trade-space exploration
 - Provides physics-based analysis tools to assess the feasibility of the design options
- CREATE augments “failure data from live tests” with “predictions 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

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

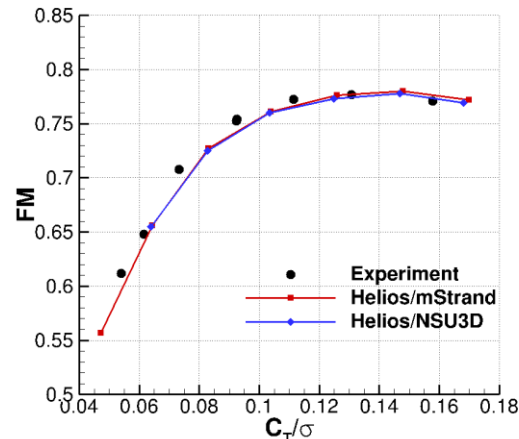
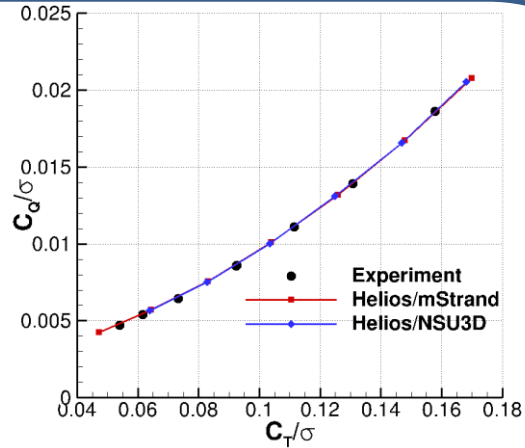
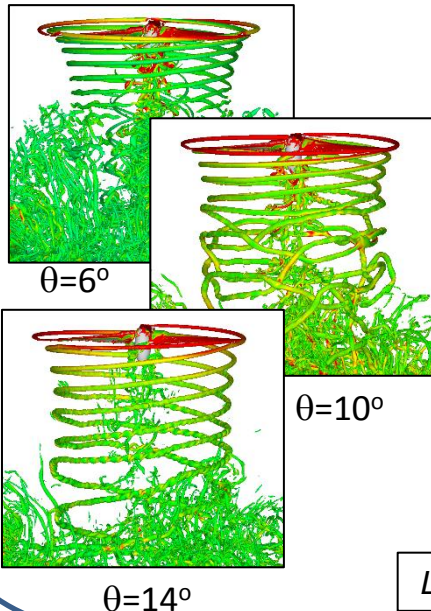
- Increased capability annually
- Extensive beta-tests of each release
- Rigorous V&V process
- Improved scalability for massively parallel computers
- Improved usability
- Responsive to evolving requirements
- Extensive documentation



CREATE Codes are Extensively Verified and Validated Before Release

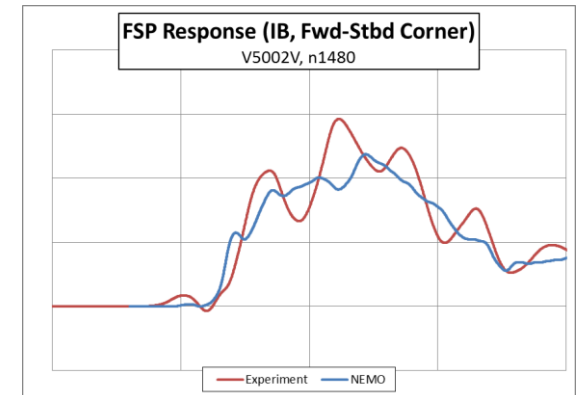
- Each code release undergoes extensive α and β tests and a multi-month product acceptance process.

Helios validation with single rotor experiments



Lakshminarayan et al AIAA-2016-1581

NESM validated with shock test data



Floating Shock Platform (FSP)

CREATE Tools Are Being Widely Adopted!

- ~600 active software licenses in FY16 (single and group)
- Over 160 DoD engineering organizations (government

Project	No.	Type of organization	Number	%	Use	%(multi-use)
Ships	40	Government/DoD	65	40%	Acquisition	48%
AV	57	Industry	80	50%	S&T	43%
RF	59	Academia/Education	19	10%	T&E	30%
GV	3				Intelligence Engineering Analysis	27%
MG	5 (+all)	Total	164		Education	4%

Supported by the 180 CREATE Staff

- **CREATE being applied to ~ 100 DoD weapon systems**
 - ~ 70 unclassified and ~ 30 classified, including almost all the major DoD air and sea vehicle systems (AF, NAVAIR, Army Aviation, and NAVSEA)
- **Enabling DoD programs: ERS, Computational Prototyping Environment (CPE), Service Acquisition**

CREATE Tools Impacting DoD Programs

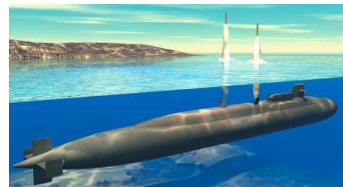
NAVSEA



DDG-1000



CVN-78 Class

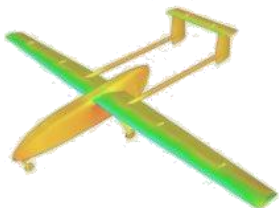


Ohio SSBN Replacement



LX(R)

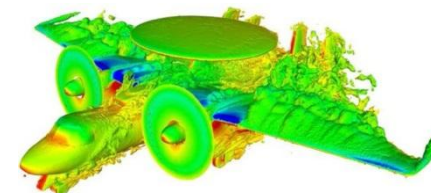
NAVAIR



Aerostar & Raven UAVs



F/A-18 E/F/G



E-2D

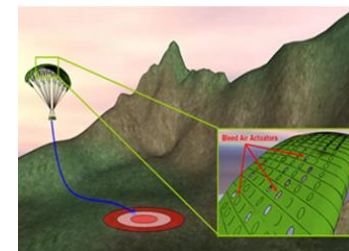
ARMY/USMC



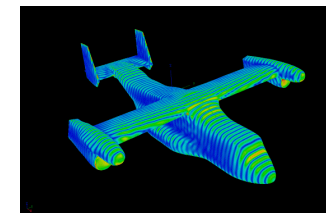
UH-60



CH-47 (ACRB)



Guided Airdrop (RDECOM)

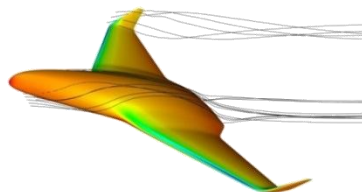


V-22

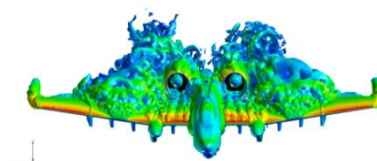
AFLCMC



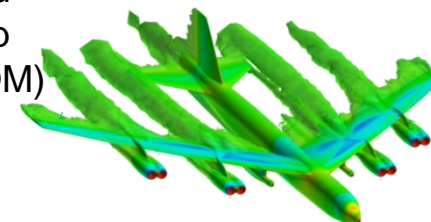
F-15 SA/DB-110



Strategic Airlift CP&A



A-10



B-52

CREATE Support of ERS Studies

CREATE tools have played important roles in the work described in the ERS presentations in the ERS track at this conference:

- M. Moulton—19015 (AMRDEC/PM-UAS) — Leveraging Modeling and Simulation to Impact Rotorcraft Acquisition—**Helios**
- A. Gray—19009 (NSWCCD) — Advances in an Early-Stage Resilient Submarine Design Capability—**RSDE (including ASSET, LEAPS and SHCP-L) and IHDE**
- C. Oster—19902 (Lockheed Martin) — ERS Methodology Development and Architectural Assessment via Efficient Supersonic Air Vehicle — **Capstone and Kestrel**
- A. Hinsdale—18910 (Raytheon) — Trade Space Analytics: The Future of Systems Engineering
- M. Castanier—19035 (TARDEC)—Using ERS Tools for Trade Space Exploration of Military GVs—**CREATE Ground Vehicles**

CREATE Ships Support of

ERS

ERS was a full or partial sponsor of 3 Navy Design Studies that used 4 CREATE-Ships Design Tools: RSDE (with LEAPS, ASSET and SHCP-L), and IHDE:

1. Comparison of Set-based design and point based design. Demonstrated the value of a set-based design process over a traditional point-based, spiral design process.

2. LX(R) Analysis of Alternatives Design Space Exploration Project Informed LX(R) requirements development and impacted selection of concept design for LX(R) in post-milestone A.



3. Small Surface Combatant Task Force. Investigated ship concept alternatives and impacted selection of Frigate concept into Post-Milestone A. ERS staff provided visualization of the data produced by the study participants and supported merger of combat systems data set with a RSDE behavior model database.

• ERS also funded software architecture development for a new RSDE submarine concept design capability planned for a FY17 start.

CREATE Air Vehicles Support of

ERS

- ERS sponsored 4 design studies and development projects that used at least one of three DoD HPMCP CREATE-AV Design Tools (Kestrel, and Helios) & CREATE MG Capstone.

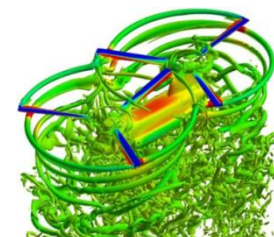
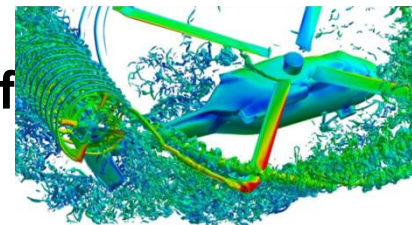
1. AMRDEC, Aviation Engineering Directorate (AED). Army Black Hawk H-60 Tail Rotor Effectiveness Study using Helios.
2. AMRDEC, AED. Army CH-47 Dynamic Hub and Pitch-Link Loads study using Helios.
3. AMRDEC, AED. CH-47 Block II Program Mission Analysis using Helios.
4. AMRDEC, AED. Assessment of Gray Eagle Flight Performance Prediction using Kestrel.

And Capstone

ERDC, ERS. Environmental Simulator—Capability to provide terrain and environmental data for land and amphibious vehicle operat
Capstone provides meshing capability for the Environmental Simulator.



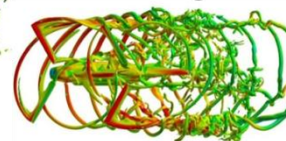
Black Hawk H-60



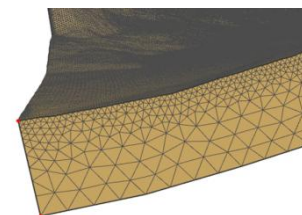
CH-47 Hover



Forward Flight



GA MQ-1C Gray Eagle



Mesh for ground

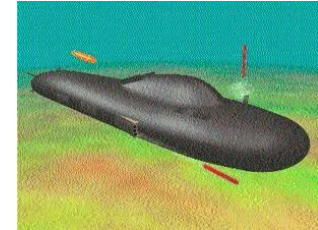
CREATE--Looking to the Future

Areas for near-term impact:



- **Hypersonics**: Investments are impacting current and future timeframes (CREATE- AV Kestrel potential)

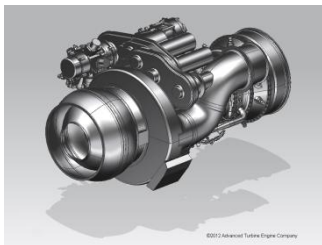
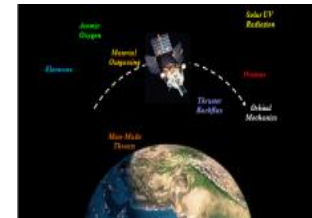
- **New Submarine Development**: Planning and design work is starting now (CREATE-Ships RSDE potential) with ERS help



- **Vertical Heavy Lift (JMR-TD)**: Critical capability for the future. Involves both manned and unmanned capabilities. All Service issue for future force structure planning and operational execution. (CREATE-AV Helios has been used for the down-select from 4 to 2 concepts)

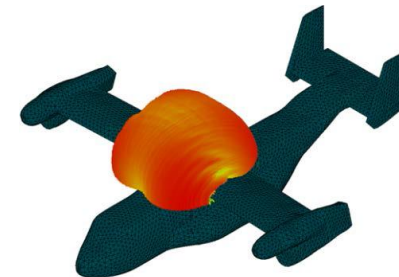


- **Space Technology**: critical design space exploration impacting all Services (e.g. satellites, weapons, sensors, etc.)



- **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

- CREATE is providing a set of physics-based engineering modeling tools focused on Service needs in aviation, maritime, ground, and electromagnetic warfare domains
 - Excellent growth potential for CREATE tools in all domains for the future
- CREATE tools: **Government-developed, government-owned, and government-supported**
 - CREATE is providing important support for ERS
 - Adoption of CREATE tools is expanding across government, industry, and academic enterprises