Engineered Resilient Systems (ERS) Overview

Model-Based Enterprise Summit 2013
NIST, Gaithersburg, MD
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ERS

Engineered Resilient Systems

Integrated Lifecycle Engineering

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What is a "Resilient" System?

A Resilient System…

- *is trusted and effective in a wide range of contexts,*
- *is easily adapted to many others through reconfiguration or replacement, and*
- *has predictable degradation of function.*

C-130 Hercules

AC-130A
Drone Control

EC-130E
Airborne battlefield command and control & electronic warfare

HC-130H
Maritime and Ice Patrol

JC-130
Mid-air Retrieval

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Defense Strategy

Technology Needs

1. Mitigate new and emerging capabilities
- Electronic Warfare
- Cyber
- Counter Space
- Counter-WMD

2. Affordably enable new or extended capabilities in existing military systems
- Systems Engineering
- Data Reuse
- Engineered Resilient Systems
- Developmental Test & Evaluation

3. Develop technology surprise through science and engineering
- Autonomy
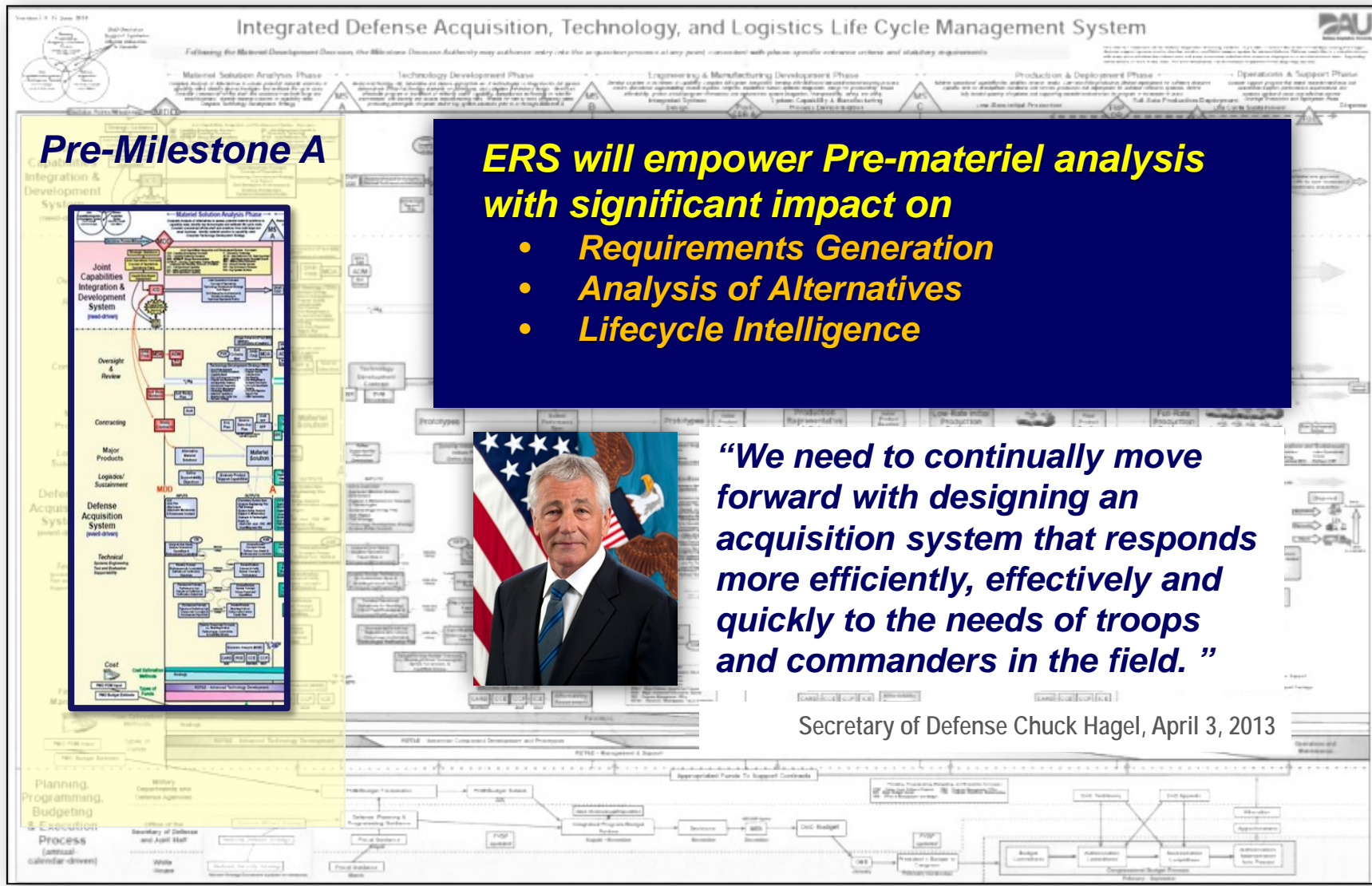- Basic Research
- Data-to-Decisions
- Human Systems

- Middle East Instability
- North Korean Nuclear Ambitions
- Anti-Access/Area Denial
- Cyber Attacks
- Electronic Warfare

Mr. Al Shaffer, Principal Deputy, ASD Research and Engineering
October 29, 2013

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ERS Addressing the Acquisition Challenge

Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System

Pre-Milestone A

ERS will empower Pre-materiel analysis with significant impact on
- **Requirements Generation**
- **Analysis of Alternatives**
- **Lifecycle Intelligence**

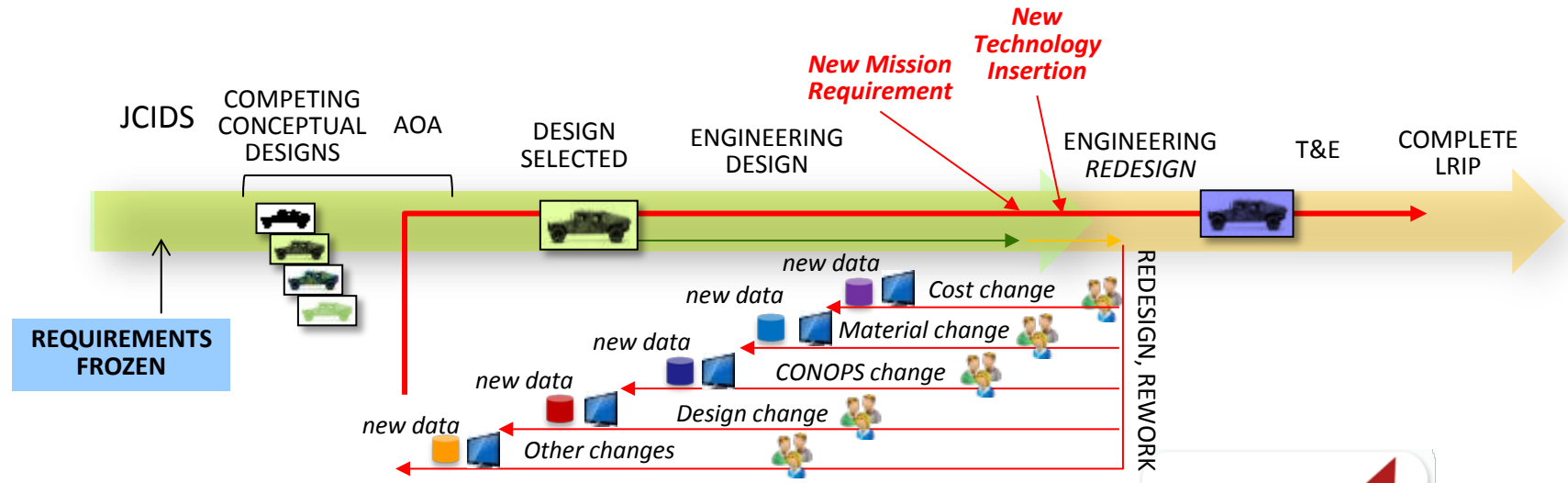*"We need to continually move forward with designing an acquisition system that responds more efficiently, effectively and quickly to the needs of troops and commanders in the field."*

Secretary of Defense Chuck Hagel, April 3, 2013

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Today: Process-driven

- *Stove-piped workforce and data sources*
- *Redundant processes*
- *Little data reuse*
- *Inefficient: both time and cost*
- *Lacks adaptability to new requirements/missions*

Negative time and cost impact

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ERS: *Data*-driven

Training · Engineering · Cost Analyst

Acquisition · Users

COLLABORATION CAPABILITIES

Portal

Enter data once
Leverage throughout lifecycle

Common Core Platforms

Framework Interface

Rapid, Reconfigurable Systems
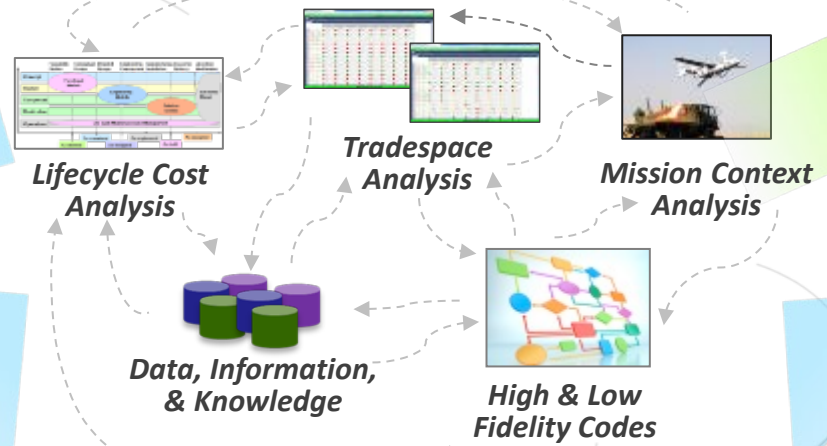
Lifecycle Cost Analysis

Tradespace Analysis

Mission Context Analysis

Needs (...ilities)

- Manufacturability
- Affordability
- Reliability
- Sustainability
- Usability
- Testability
- Etc.

Data, Information, & Knowledge

High & Low Fidelity Codes

HPCMP Resources

Previous Design Successes, Lessons-learned

S&T Resources, Research

Data-driven Decisions

1. REQUIREMENTS 2. CONCEPTUAL MODELING 3. SYSTEM CONFIGURATION 4. ALTERNATIVE ANALYSIS 5. COST ASSESSMENT 6. IMPACT ANALYSIS

Millions of Possible Designs

- Capture Needs & Requirements
- Create a project
- Build team
- List of potential project team Members from Knowledge Hub
- Complete conceptual model - SysML
- Develop conceptual model of the system
- Team evolves system ontology
- Configure Orchestrator
- Assemble all model packages
- Publish SysML (Block and Parametric Diagram)
- Create Orchestrator start file
- Identify Design Alternatives
- Execute Decision Analyzer
- Tradespace Exploration
- Cont.
- Assess lifecycle cost of alternatives
- Mission Context Analysis
- Cont.

A set of designs with a known and acceptable satisfaction and risk

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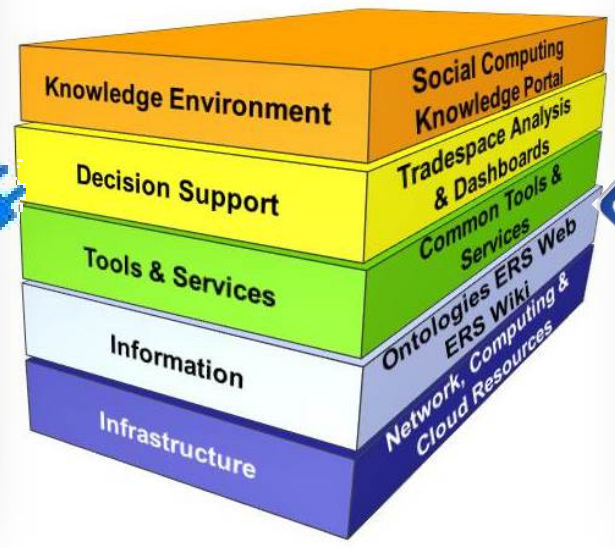
ERS Framework Concept

Needs/Requirements

Army
Tools, Information & Infrastructure

Air Force
Tools, Information & Infrastructure

Navy
Tools, Information, & Infrastructure

Sensors
Ground Vehicles
Aircraft
Ships

Pre-Milestone A Systems Engineering

Framework Standards

ERS Framework

Knowledge Environment — Social Computing Knowledge Portal

Decision Support — Tradespace Analysis & Dashboards

Tools & Services — Common Tools & Services

Information — Ontologies ERS Web ERS Wiki

Infrastructure — Network, Computing & Cloud Resources

Open Architecture Common Environment Shared Capabilities Enables Collaboration

Framework Interface

Acquisition

Acquisition Program

Acquisition Program

Acquisition Program

Acquisition teams leverage ERS capabilities throughout the systems lifecycle

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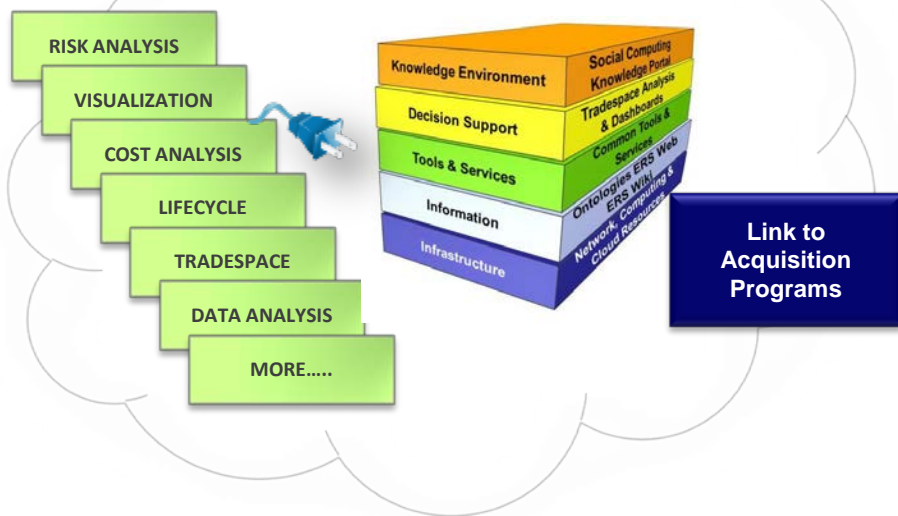
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Major ERS Components
ERS Technology Anchors

ERS Framework and Open Architecture

– **Connects existing tools, information, and data in a common framework**

– **Acquisition teams leverage ERS capabilities throughout the system lifecycle**

Link to Acquisition Programs

Tradespace Analysis

– **Enables informed decisions**

– **Empowers AoA and Requirements Generation**

– **"Visualizes" trades of many more designs in far less time**

MISSION CONTEXT

TRADE DESIGN ELEMENTS

Sensitivity & Confidence Analysis

Throughout Product Lifecycle
Design → Disposal

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Architecture Roadmap

Legend:
- Apply
- Leverage
- Build

ERS Capability Analysis
- LEAPS (USN)
- FACT (USMC)
- DaVinci
- Kestrel
- WSTAT
- Erc.

Conceptual Modeling
- Ontologies describe system and trades
- Computation for tradespace calculation in SysML

Navy applies ontology modeler to LEAPS

Advance Visualization (HPCMO)
ParaView provides insights into myriad data generated in analyses

Manufacturability (solicitation)
Analytics to assess manufacturability

Risk and Uncertainty
Measure and display risk associated with designs

Knowledge Manager
Interface decision support tools.

Analysis of Alternatives
Display, discuss, select among alternative systems

Lifecycle Cost Analysis
Cost analytics integrated in tradespace

Orchestrator
Execution manager oversees processing of user inputs into results

Teaming
Methods to adapt teams to design process

Assess knowledge management needs and requirements

Pilot KM functions

Decision Visualization
Visualizes models (graphs, charts, 3-D objects)

Implementation Timeline

FACT selected as baseline for future ERS development

Establish ERS computing enclave

Establish hosting environment for Navy

Model Integration
Method to integrate models: 1) simplification to meta-models, 2) meta-models packaged, hosted on ERS environment

Needs Analysis
Conducted with the Navy, Air Force and Marine Corp

HPC Interface
Machine-to-machine connectivity (HPC and non-HPC resources)

HPC Interoperability (HPCMO)
Non-HPC machines interoperable with HPC resources

CREATE (HPCMO)
Deploy advanced computational design tools:
CREATE – Air Vehicles, -Ships, -Antennas, -Meshing and Geometry

CRES-GV (HPCMO)
High-fidelity design/analysis tools for ground vehicles

Environmental Simulator (EnvSim) (ERDC)
Physics-based codes to create a digital representation of an environment

Mission Context Analysis
System performance within a simulated mission

M&S (DoD)
Suite of DoD modeling and simulation capabilities

Release 1 FY14

Release 2 FY15

Future Releases FY16+

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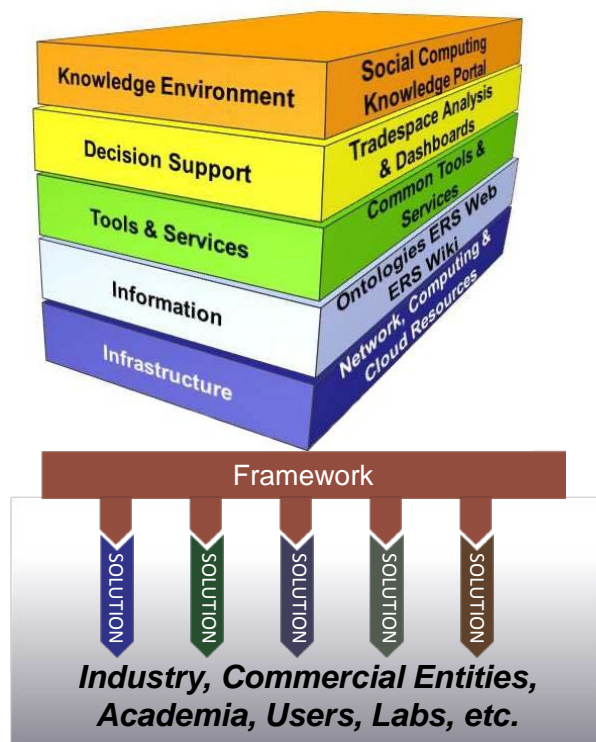
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ERS Architecture Attributes

> ### *"Open System Architecture is a key contributor to Resilient Design."*
> #### *Mr. Stephen P. Welby, Deputy Assistant Secretary of Defense for Systems Engineering*

- **Non-proprietary, open framework**
- **Interactive with outside entities (API)**
- **Platform agnostic**
- **System—not Service—centric**
- **Multi-fidelity analysis**
- **Legacy system compatibility**
- **Shares benefit of R&D among users**

Industry, Commercial Entities, Academia, Users, Labs, etc.

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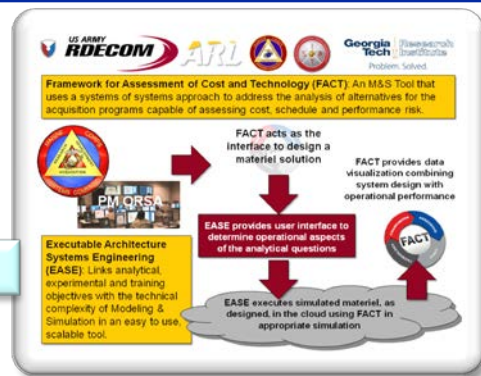
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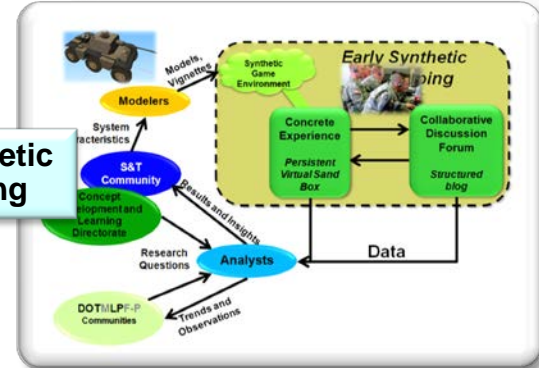# Tradespace Analysis Goals

Develop a prototype tool linking Mission Context and Tradespace tools into a combined system
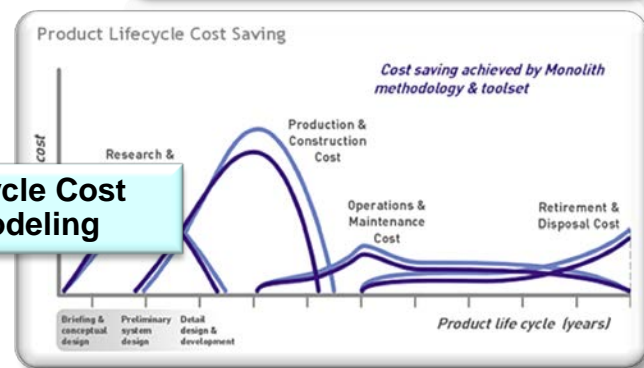
FACT-EASE

Demonstrate collection and validation of capabilities requirements in virtual and synthetic environments
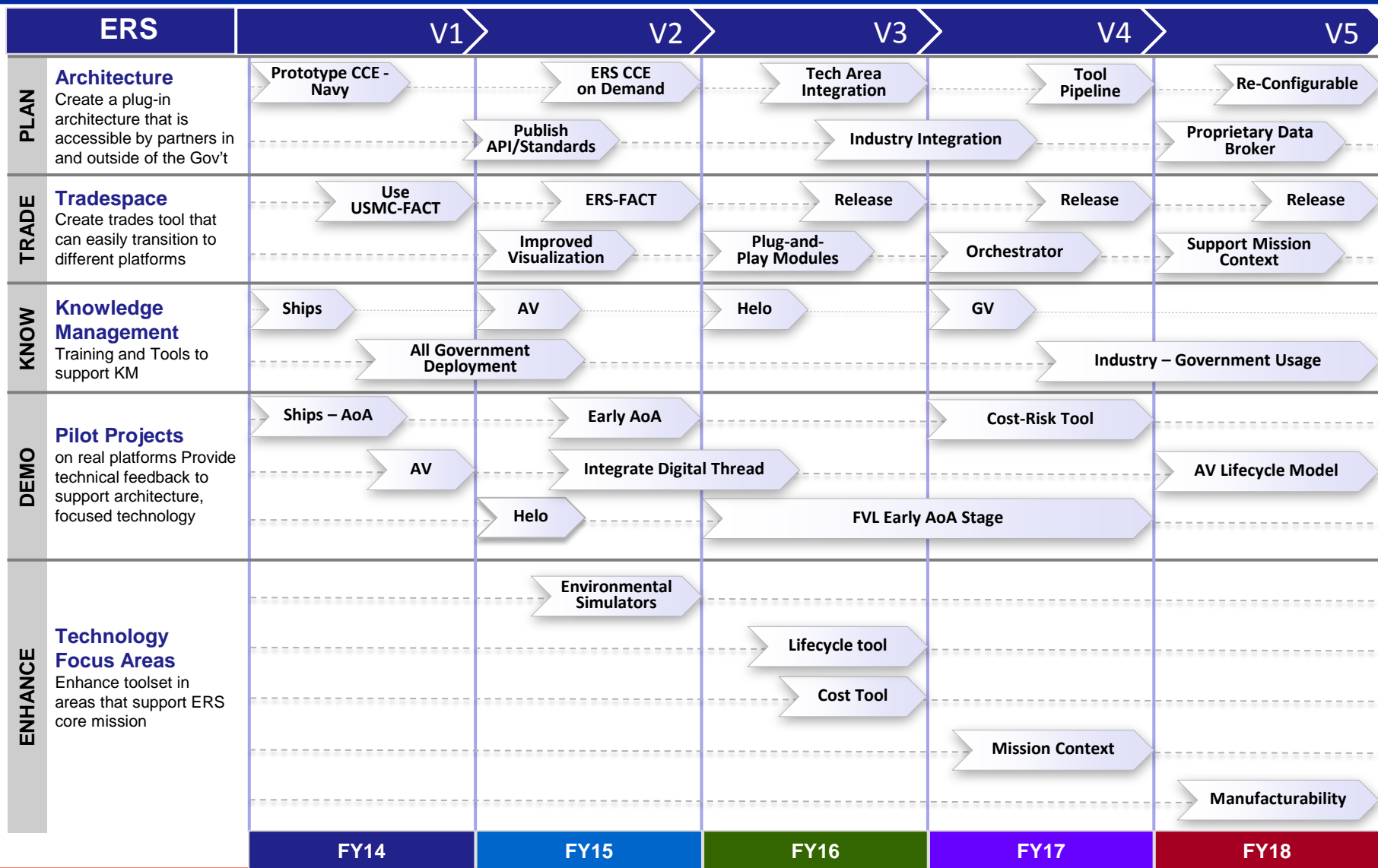
Early Synthetic Prototyping

Map the current lifecycle cost mythologies to more fully understand the process, and

Draft a strategy and lifecycle cost model(s) based on stakeholder values

Lifecycle Cost Modeling

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ERS Roadmap (FY14 - FY18)

ERS	V1	V2	V3	V4	V5
PLAN — **Architecture** Create a plug-in architecture that is accessible by partners in and outside of the Gov't	Prototype CCE - Navy	ERS CCE on Demand / Publish API/Standards	Tech Area Integration / Industry Integration	Tool Pipeline	Re-Configurable / Proprietary Data Broker
TRADE — **Tradespace** Create trades tool that can easily transition to different platforms	Use USMC-FACT	ERS-FACT / Improved Visualization	Release / Plug-and-Play Modules	Release / Orchestrator	Release / Support Mission Context
KNOW — **Knowledge Management** Training and Tools to support KM	Ships	AV / All Government Deployment	Helo	GV / Industry – Government Usage	
DEMO — **Pilot Projects** on real platforms Provide technical feedback to support architecture, focused technology	Ships – AoA / AV	Early AoA / Integrate Digital Thread / Helo	Cost-Risk Tool / FVL Early AoA Stage	Cost-Risk Tool	AV Lifecycle Model
ENHANCE — **Technology Focus Areas** Enhance toolset in areas that support ERS core mission		Environmental Simulators	Lifecycle tool / Cost Tool	Mission Context	Manufacturability

FY14	FY15	FY16	FY17	FY18

FY14-15 Technical Milestones
Building Components & Integrating

Quarter	Description of Milestone	Status
3QFY13	Pilot Projects: ERS Ships and AV, Phase 1	Completed
1QFY14	ERS Ships and Air Vehicle, Phase 2	In Progress
1QFY14	Initial Release: ERS Integrating Architecture (corresponds to ERS V0.1)	Planned
4QFY14	ERS V1.0 Release (Major Milestone)	Planned
4QFY15	ERS V2.0 Release (Major Milestone)	Planned

Technical Goals:

- Capture and simulate essential components of the DoD acquisition and operational analysis processes;
- Integrate M&S, collaborative tools, tradespace analysis, engineering design processes into single architecture;
- Express lessons learned and create communities of interest through DoD social media exploitation;
- Demonstrate ERS for various platforms, such as Ships, Fixed-Wing Air Vehicles, and Helicopters; and
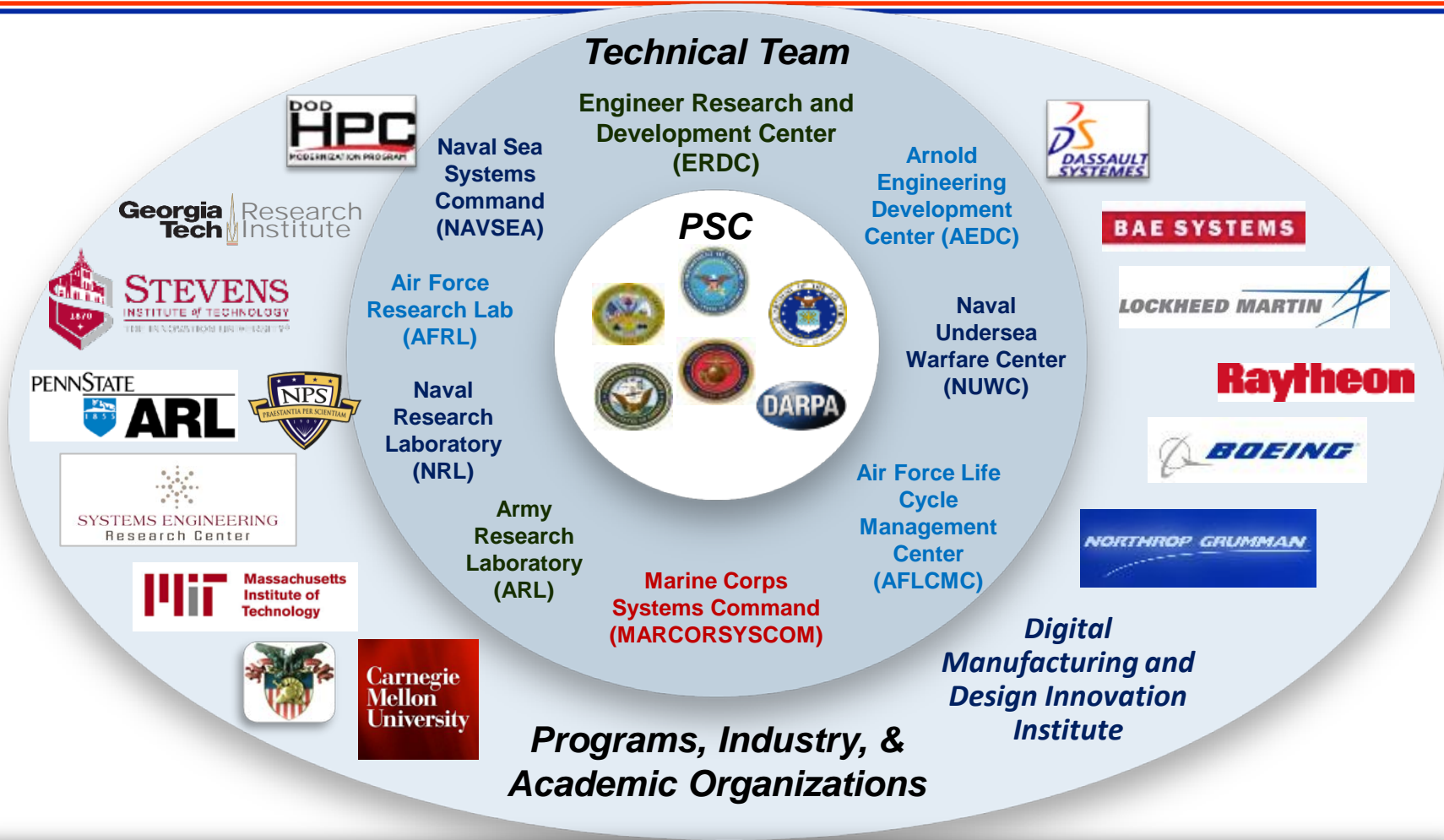- Provide the technical basis for improvements to DoD policy.

Quarter	Description of Milestone	Status
1QFY13	PSC Transition of Leadership – R. Neches to J. Holland	Completed
2QFY14	Outreach/engagement of Academia and Industry (e.g., GTRI, SERC, Lockheed Martin ATL, BAE Systems, etc.)	Complete/Task Ongoing
4QFY13	Annual General PSC Meeting to discuss FY14 Activities	Complete
1QFY14	Continue Industrial Outreach (Boeing, Northrop, Raytheon, etc.)	Planned
2QFY14	Deliver priority research topics to the SERC	Planned
2QFY14	Virtual ERS-wide Technical Workshop (VTW)	Planned
3QFY14	Hold Senior Advisory Meeting to discuss FY15 Activities	Planned
4QFY14	Annual Technical/Program Review	Planned

- The ERS Program Management team is actively engaging the Services, the DoD's industrial base, commercial tool-makers, academia and research institutes. Technical exchange between Government and industry is built into the ERS management goals.

- Engineered Resilient Systems (ERS) has developed three levels of Government engagement and support:
  - OSD serves as a surrogate for the Services and DoD in general.
  - A joint-services, Senior Advisory body will provide technical direction, guide service engagements, provides insights and opportunities related to the Services, and assist with enlistment of relevant projects.
  - ERS Working Groups will identify technical needs and gaps related to policy, standards, data and training (and issues that arise), and draft working plans to address issues.

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ERS Technical Team & Partners

Technical Team

Engineer Research and Development Center (ERDC)

Naval Sea Systems Command (NAVSEA)

Arnold Engineering Development Center (AEDC)

PSC

Air Force Research Lab (AFRL)

Naval Undersea Warfare Center (NUWC)

Naval Research Laboratory (NRL)

Army Research Laboratory (ARL)

Air Force Life Cycle Management Center (AFLCMC)

Marine Corps Systems Command (MARCORSYSCOM)

Digital Manufacturing and Design Innovation Institute

Programs, Industry, & Academic Organizations

DoD HPC — Georgia Tech Research Institute — STEVENS INSTITUTE OF TECHNOLOGY — PENNSTATE ARL — NPS — SYSTEMS ENGINEERING Research Center — MIT Massachusetts Institute of Technology — Carnegie Mellon University — DS DASSAULT SYSTEMES — BAE SYSTEMS — LOCKHEED MARTIN — Raytheon — BOEING — NORTHROP GRUMMAN

Partnering with and Leveraging Key Program Executive Offices (PEOs), Program Managers (PMs), Industry and Academia

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Contact Information

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