



# Capability Composition and Data Interoperability for Effective Results

Nickolas H. Guertin, PE

Douglas C. Schmidt, PhD

William Scherlis, PhD

Software Engineering Institute  
Carnegie Mellon University  
Pittsburgh, PA 15213

Copyright 2018 Carnegie Mellon University and William Scherlis. All Rights Reserved.

This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

The view, opinions, and/or findings contained in this material are those of the author(s) and should not be construed as an official Government position, policy, or decision, unless designated by other documentation.

References herein to any specific commercial product, process, or service by trade name, trade mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by Carnegie Mellon University or its Software Engineering Institute.

NO WARRANTY. THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

[DISTRIBUTION STATEMENT A] This material has been approved for public release and unlimited distribution. Please see Copyright notice for non-US Government use and distribution.

This material may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at [permission@sei.cmu.edu](mailto:permission@sei.cmu.edu).

Carnegie Mellon® is registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

DM18-0603

# Speed of Capability

The U.S. DoD is the envy of all nations, but ...

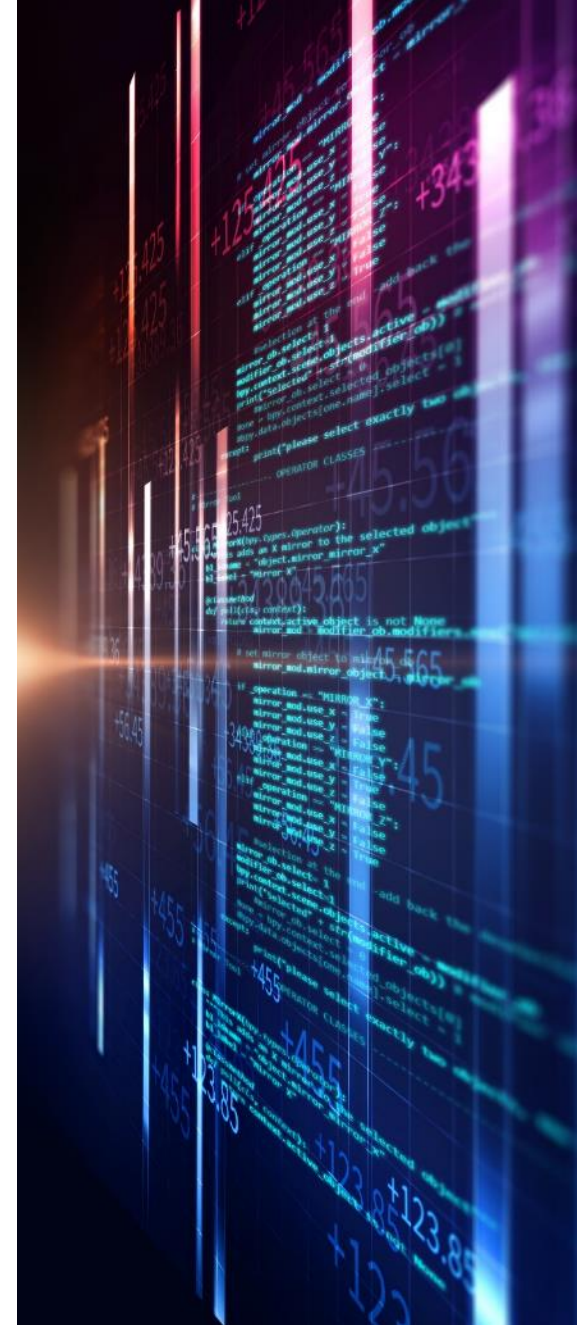
- Near-peer competitors are progressing faster than we change
  - e.g., COTS tools & building blocks are available to all
- New threats are vexing in key warfare areas



- To move faster, we need a different approach
- The environment is ripe with opportunities for new approaches

**Harness the innovation engine of the nation & the world**

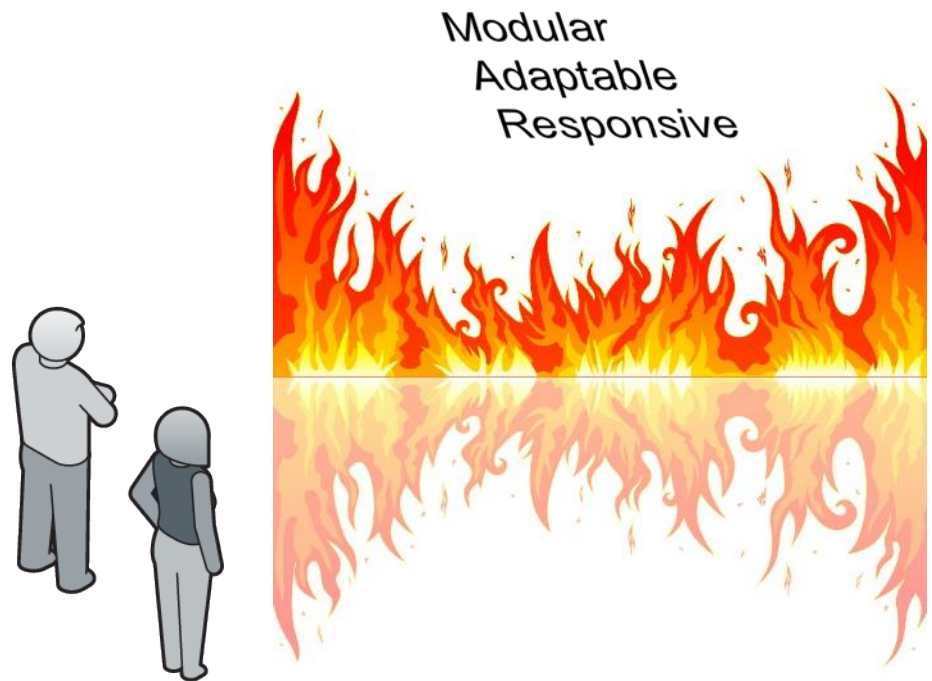
# Setting the Stage for a New Approach – What’s Different About Going Modular & Delivering Rapidly?



# Nimble Responses to Nimble Adversaries via Modularity & Rapid Delivery

Everything on the table to change the DoD acquisition ecosystem:

- Continuous change in the field
- Financial management
- Business
- Organization
- Contracts
- Incentives
- Training
- Certification
- Operations



**Establish the environments to support exquisite capability**

# Move to Modularity & All That It Means

Cyber-physical products are never done



# Move to Modularity & All That It Means

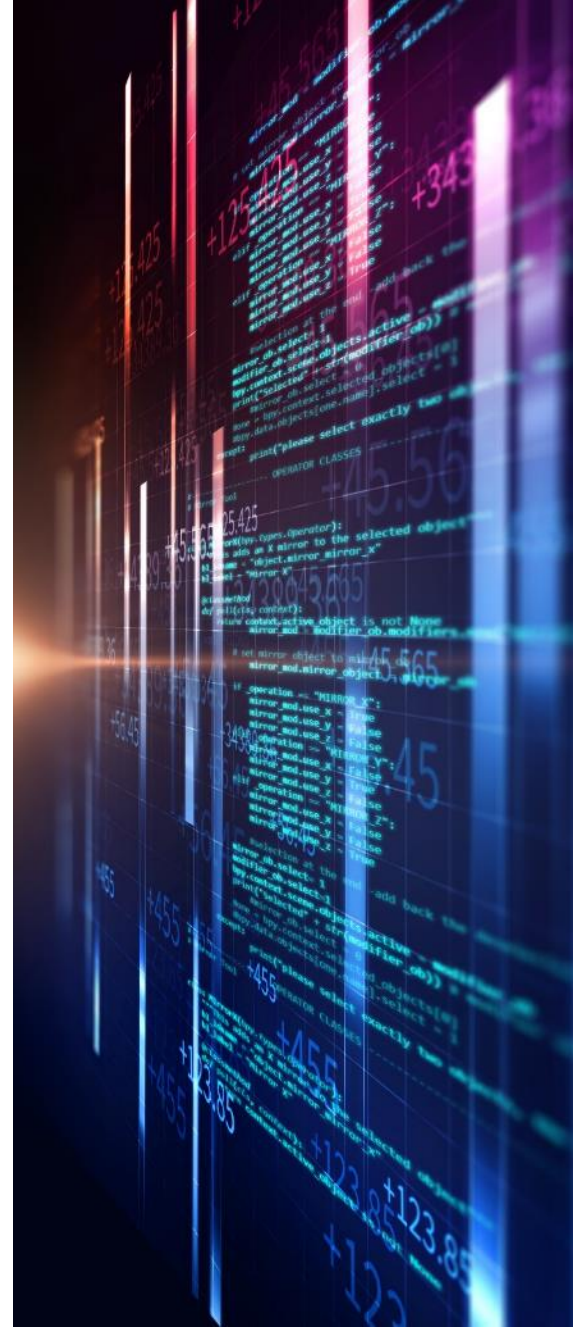
Cyber-physical products are never done

Continuous engineering & development/operations pairing

- No software part of a product ever gets to “sustainment”
- Everything is being improved throughout the lifecycle
- The new “requirement” is stable – be operationally relevant
- Capability is delivered in modules, as soon as they are ready

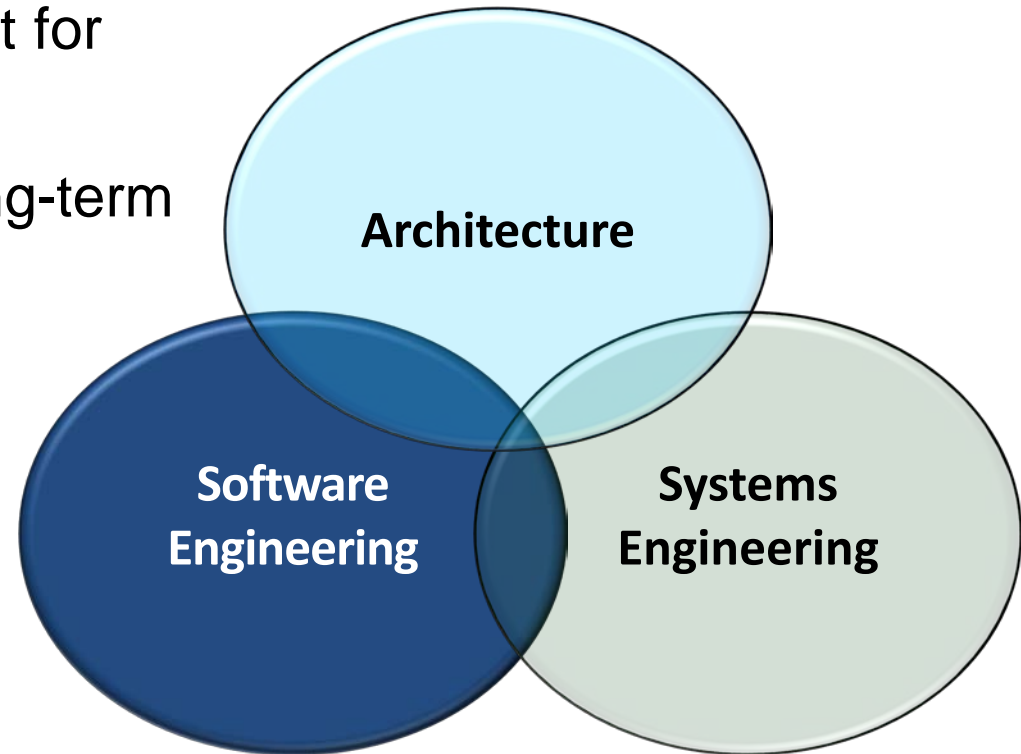


# Setting the Stage: An Architecture-Centric Approach

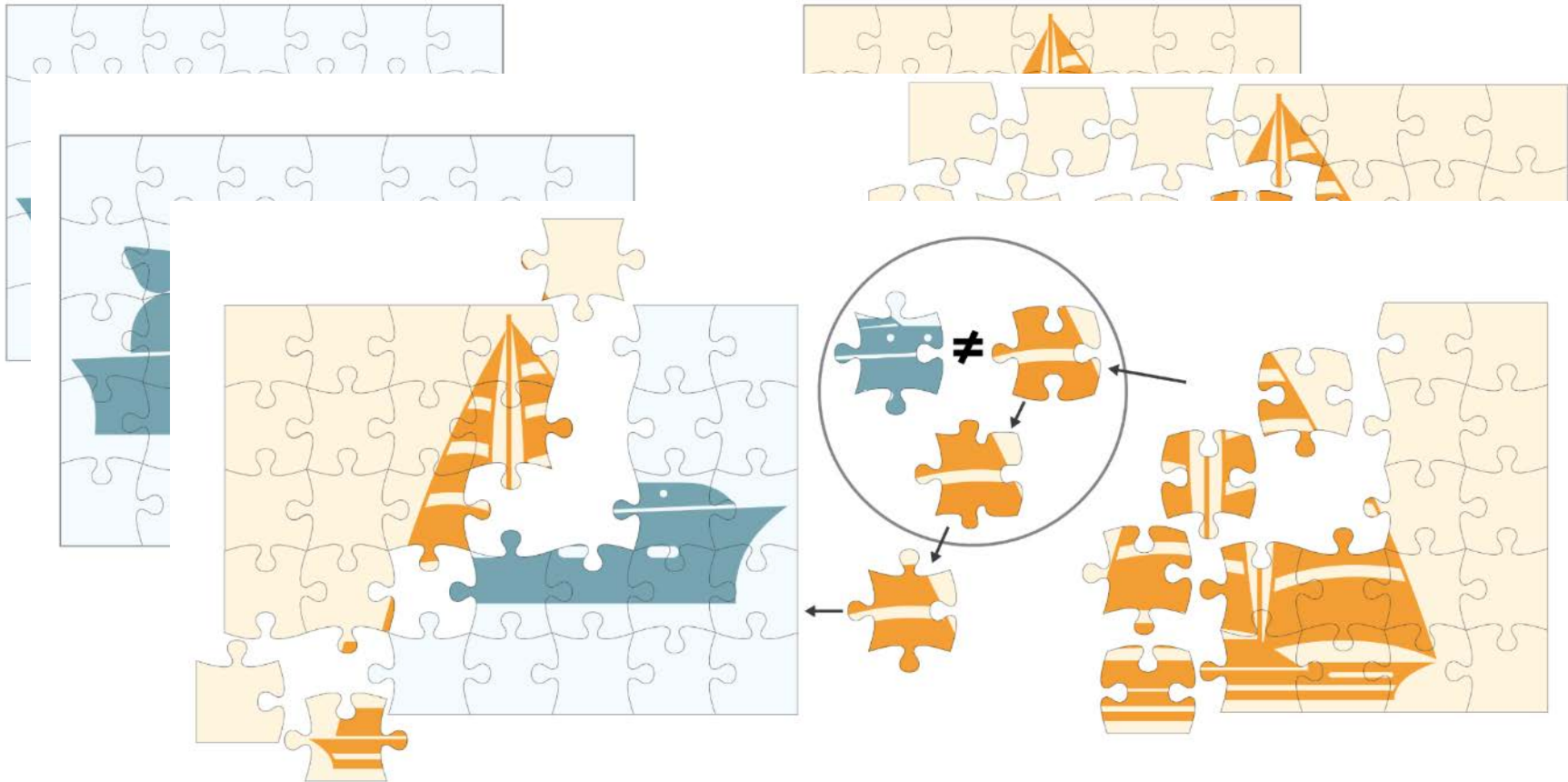


# Architecture-Centric Approach

- Address military requirement for flexibility
- Optimize trade space for long-term responsiveness & performance
- Address continuous modular improvement in design
- Identify areas for innovation growth
- Tie development to operations and warfighter responsiveness



# Purpose-Built / Tight Coupling Results in Limited Use



# Foundational Architectures Designed to Support Loose Coupling & High Cohesion



# The Power of Technical Frameworks: Avionics

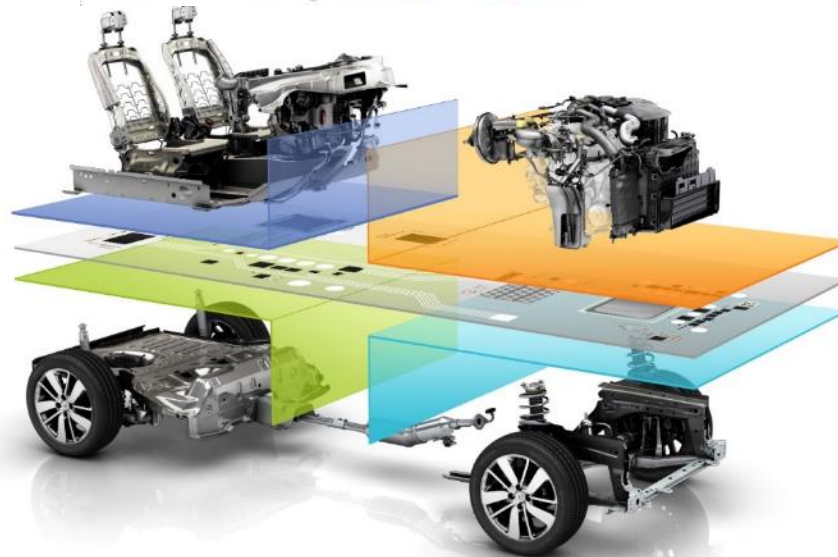
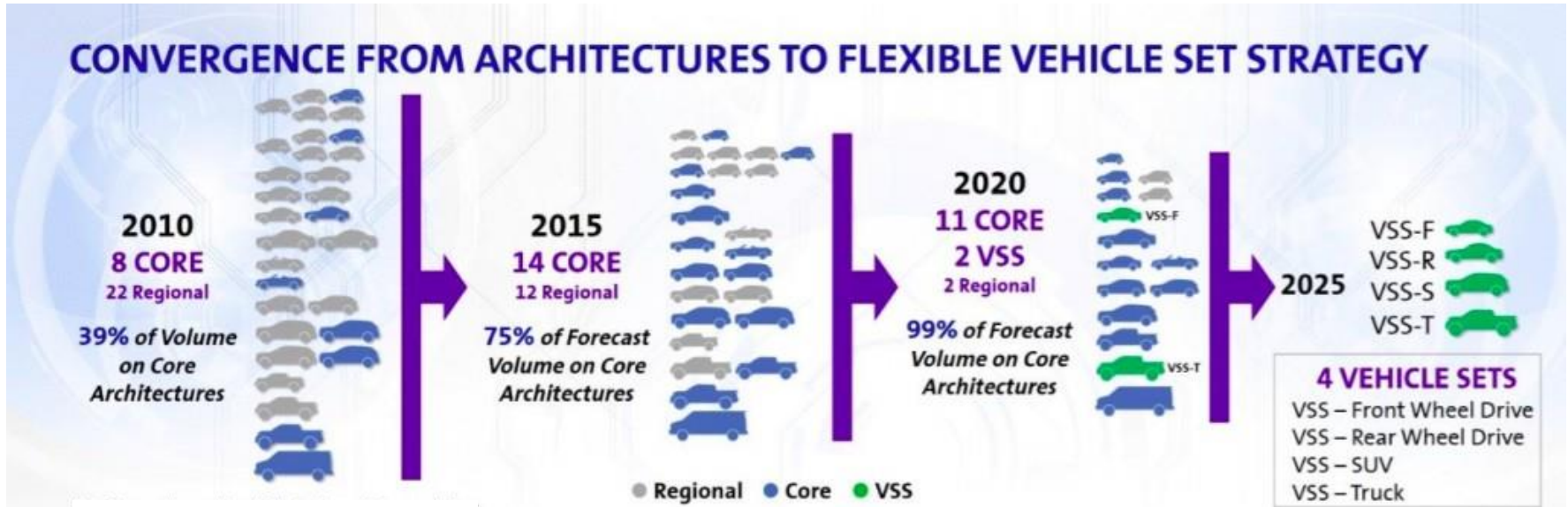


Closed / Custom / Proprietary

Open



# The Power of Technical Frameworks: Automotive



# Organizational Impacts to Going All-in to Achieve Flexibility & Speed of Delivered Capability

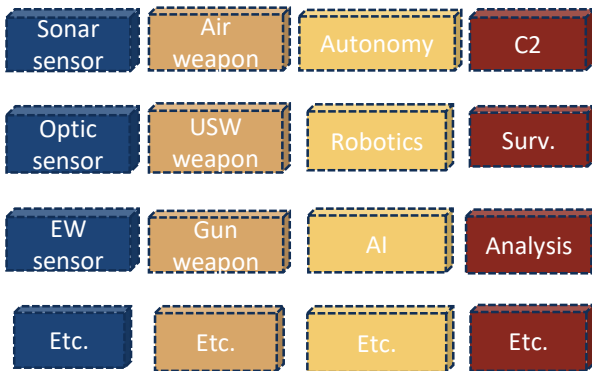


# Proposed Organizational Construct

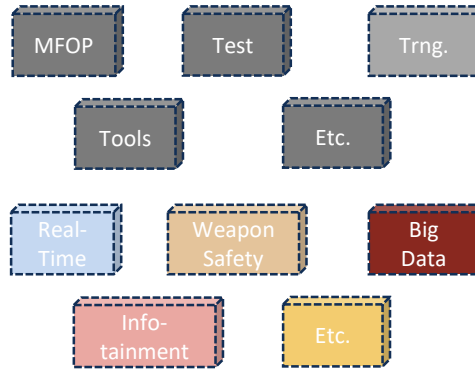
Natural alignment & separation of concerns

*Platform acquisition is the receptacle for payloads of composed module (does not develop payloads)*

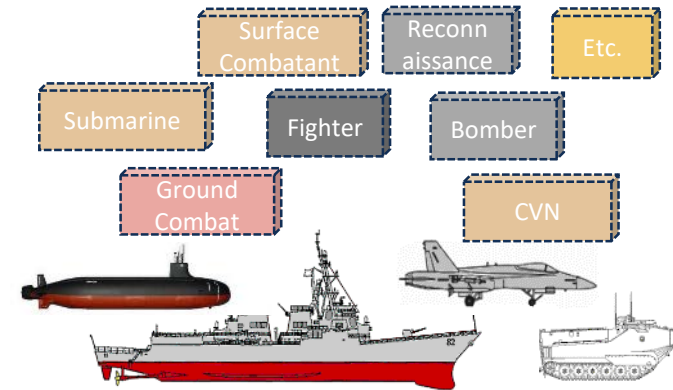
Research & Engineering  
(Payloads)



Acquisition & Sustainment  
(Architecture Frameworks)



Platform Acquisition

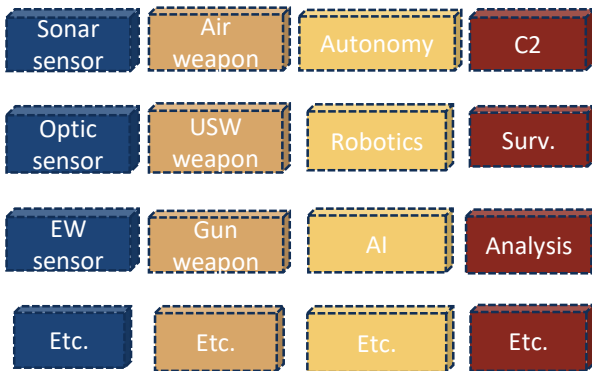


# Proposed Organizational Construct

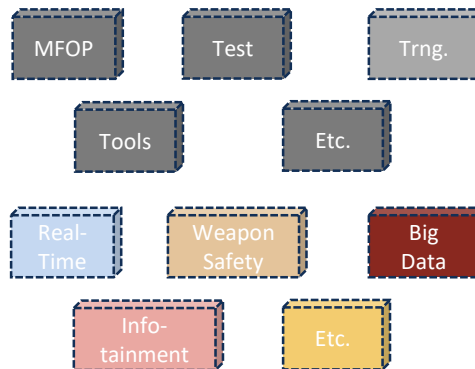
Natural alignment & separation of concerns

*R&E creates payloads out of modules to create effects (responsive to platform to create military effect)*

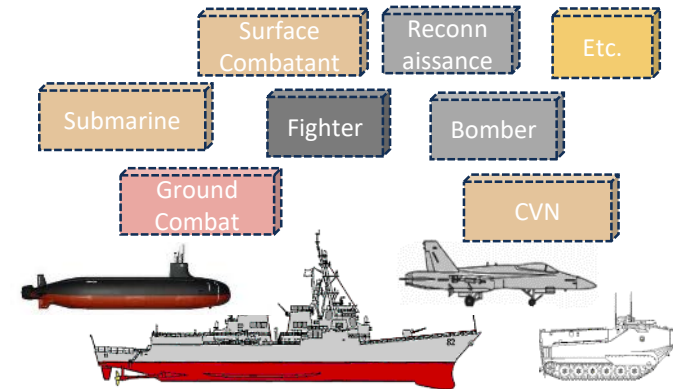
Research & Engineering (Payloads)



Acquisition & Sustainment (Architecture Frameworks)



Platform Acquisition

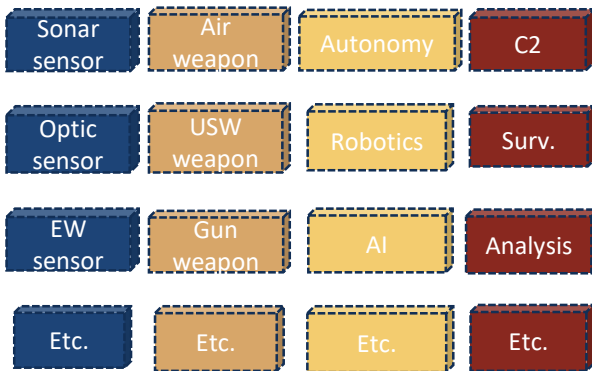


# Proposed Organizational Construct

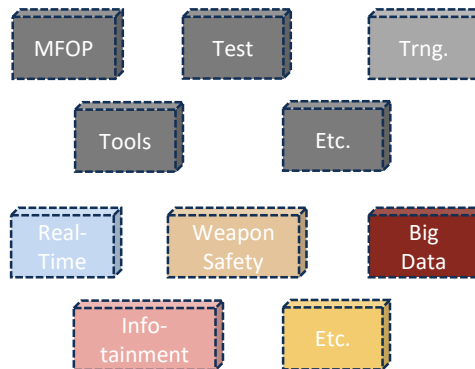
Natural alignment & separation of concerns

*A&S establishes the foundational environment to deploy modules (responsive to the needs of R&E in a way that fits the platform)*

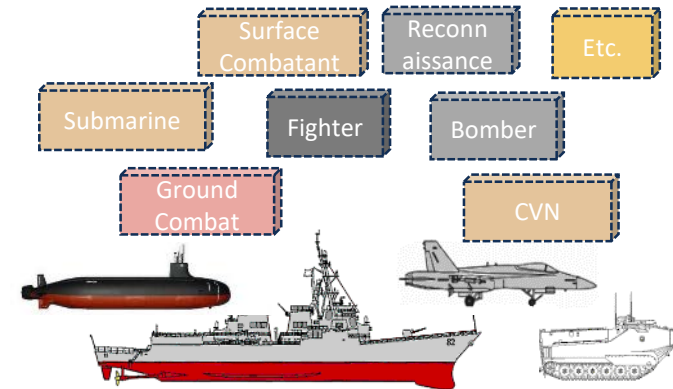
Research & Engineering (Payloads)



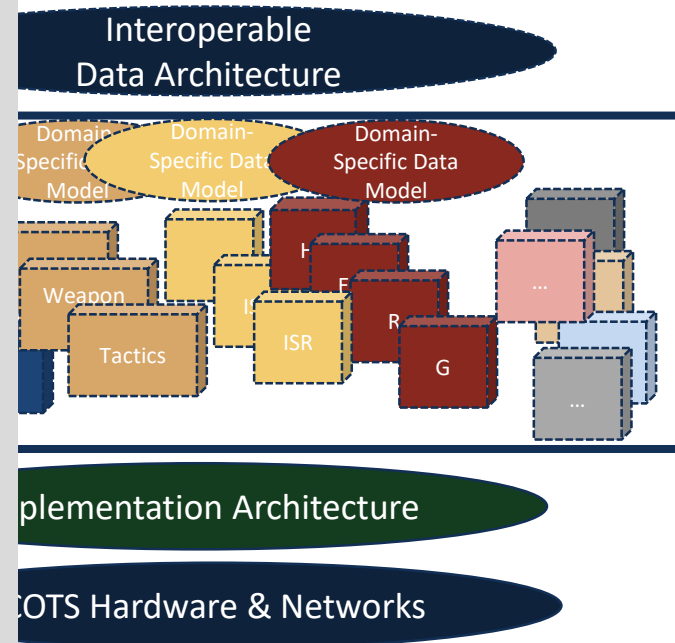
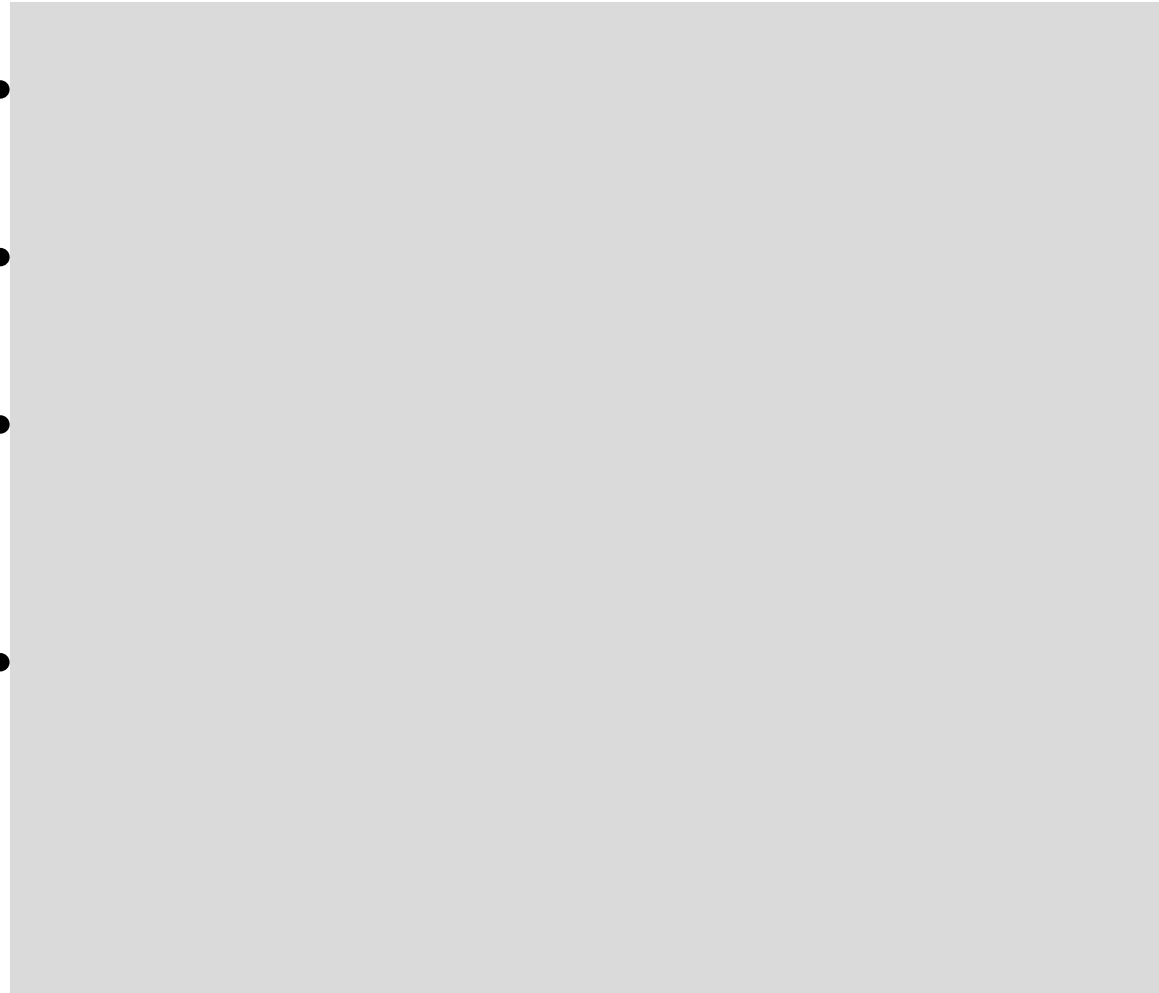
Acquisition & Sustainment (Architecture Frameworks)



Platform Acquisition



# Separation of Concerns: A&S & R&E



# Addressing Goldwater–Nichols

Service  
Chief Staff

Primary Sponsors'  
Requirements for  
Overall Platform Capability

Ships

Air

Ground

Space

Cross-Domain Payload  
Sponsors'  
Requirements for  
Payload Capability

Missile

Gun &  
DE

EM  
Spectrum

Space

ISR  
Big  
Data

CM &  
C2

Sonar

Acquisition  
Executive/Secretariate

Acquisition &  
Sustainment  
(the Catcher's Mitt)

Platform Acquisition  
Managers

Capability Commodity  
Managers

Weapon  
Safety

Combat  
Management

Real Time

Large Scale

Data  
Architecture

Ships

Air

Ground

Space

Missile

Gun &  
DE

EM  
Spectrum

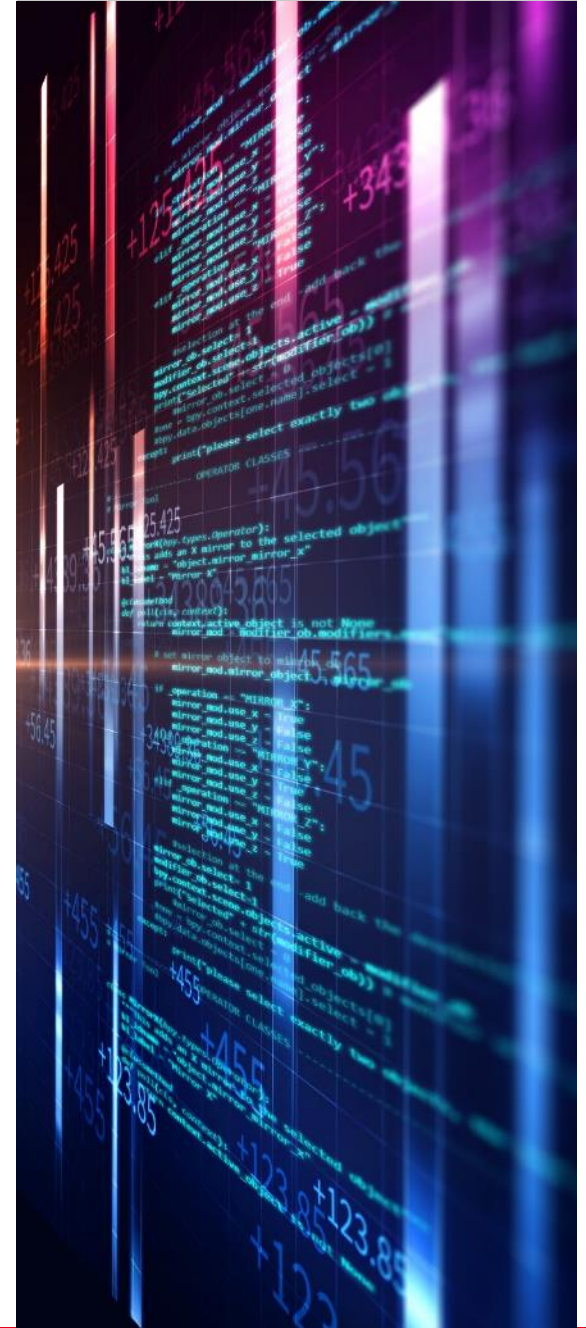
Space

ISR  
BigData

CM &  
C2

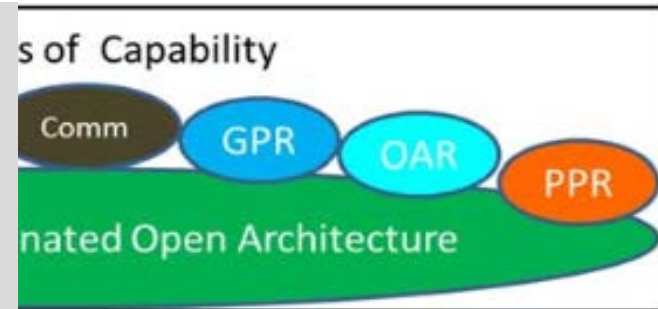
Sonar

# Business & Contracting Impacts to Going All-in on Modularity & Rapid Improvements



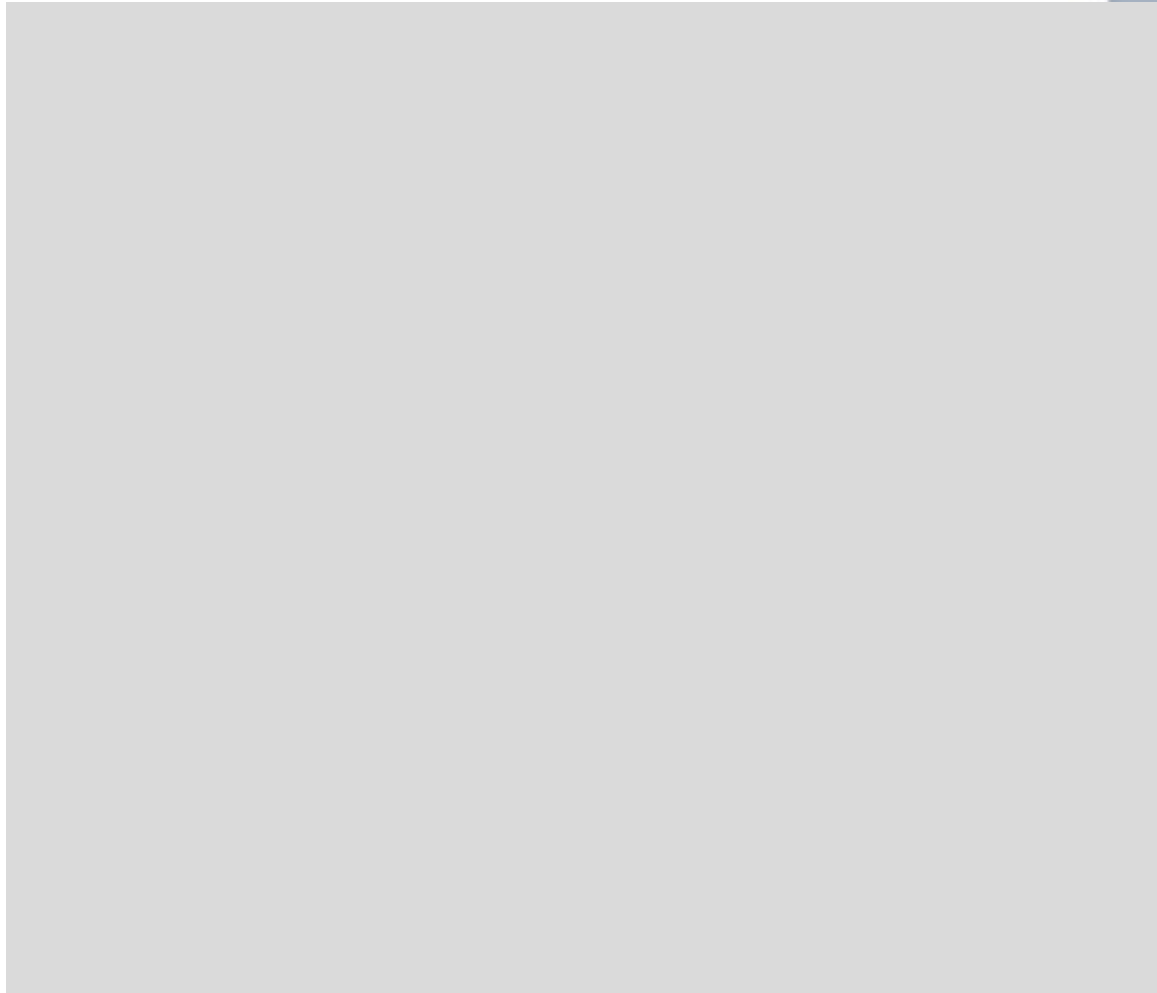
# Open Acquisition Strategy

Government is the “business integrator”



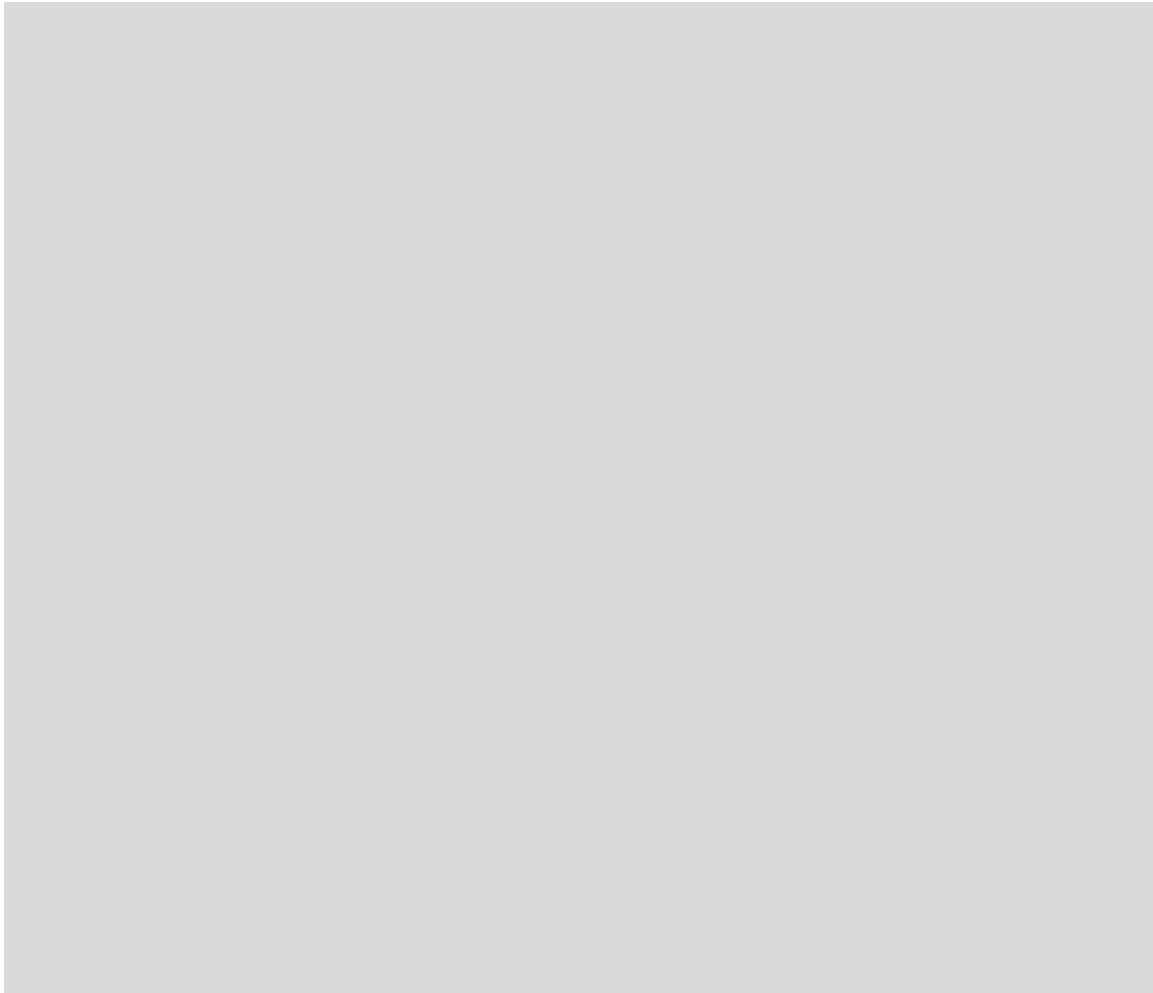
# Open Acquisition Strategy

Government is the “business integrator”

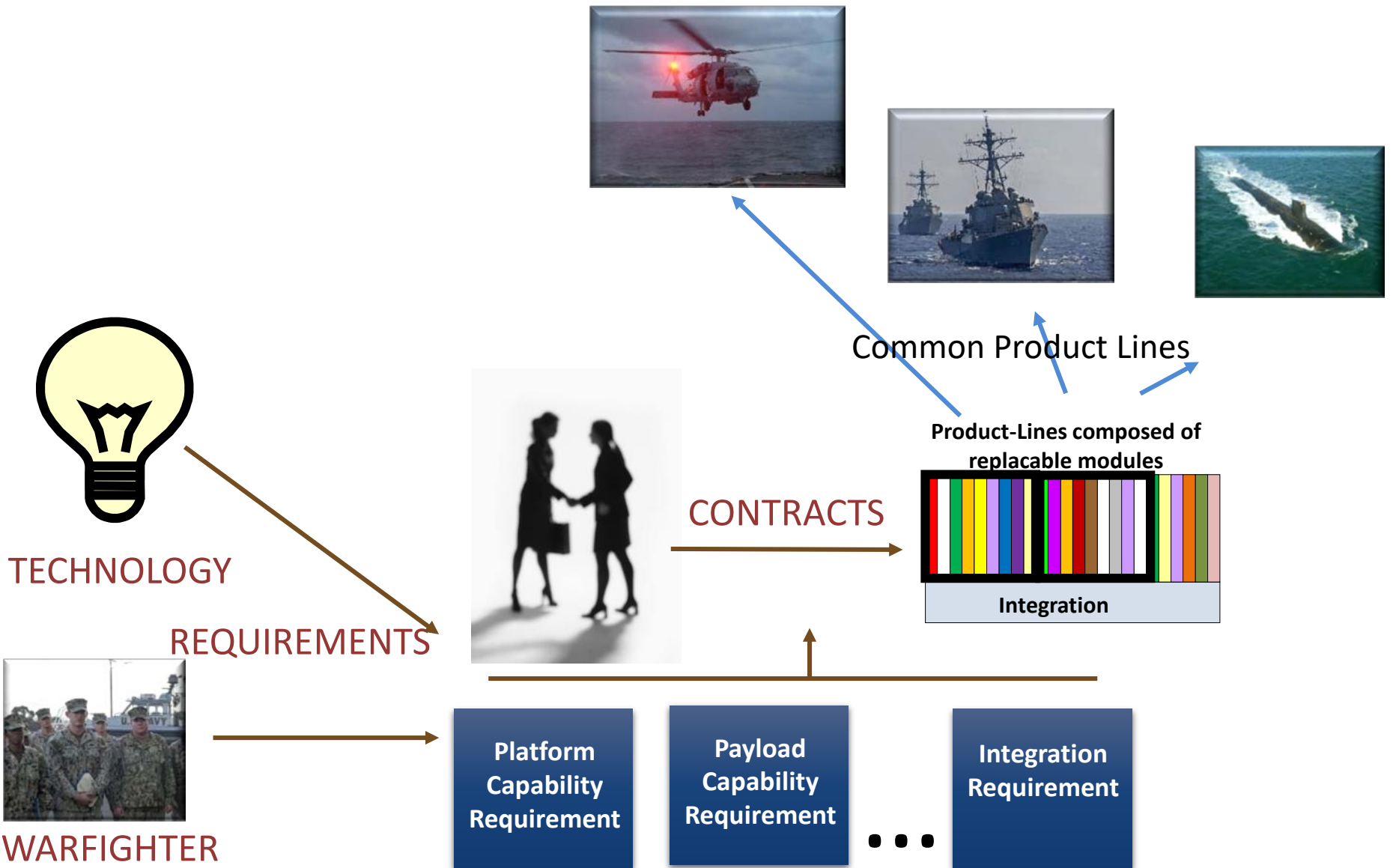


# Open Acquisition Strategy

Government is the “business integrator”



# Putting it all into motion - Contracts

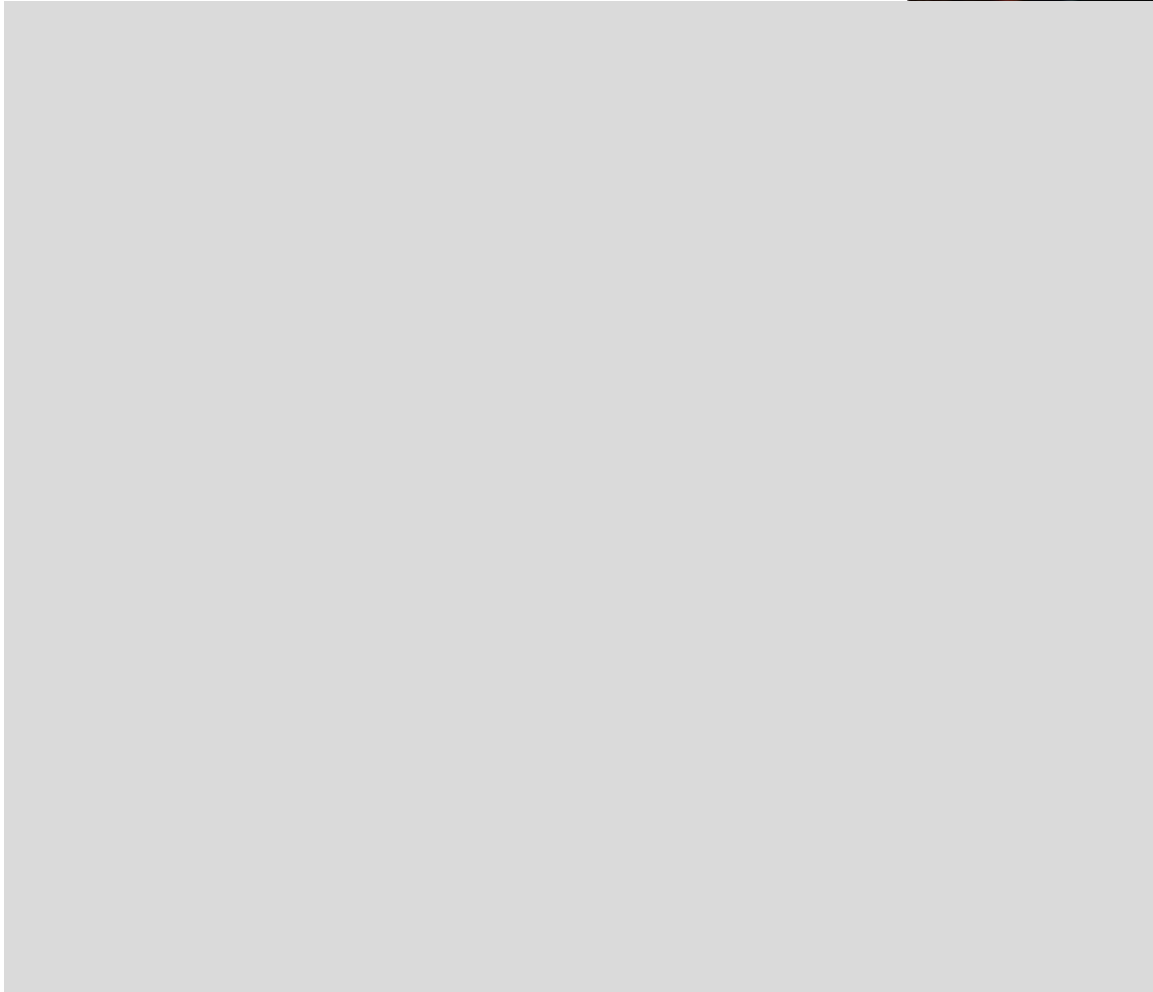






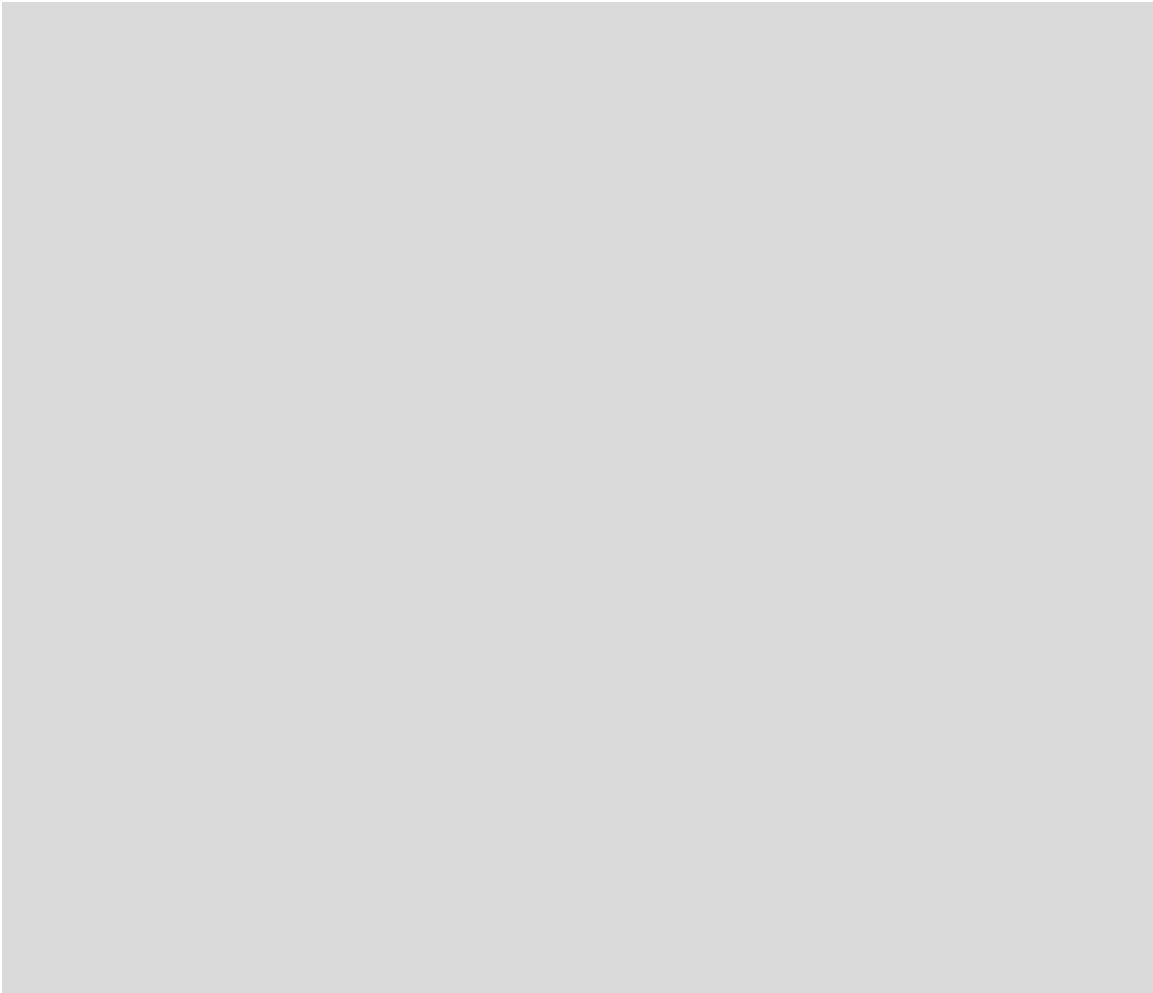
# Actions

- Establish new budgetary

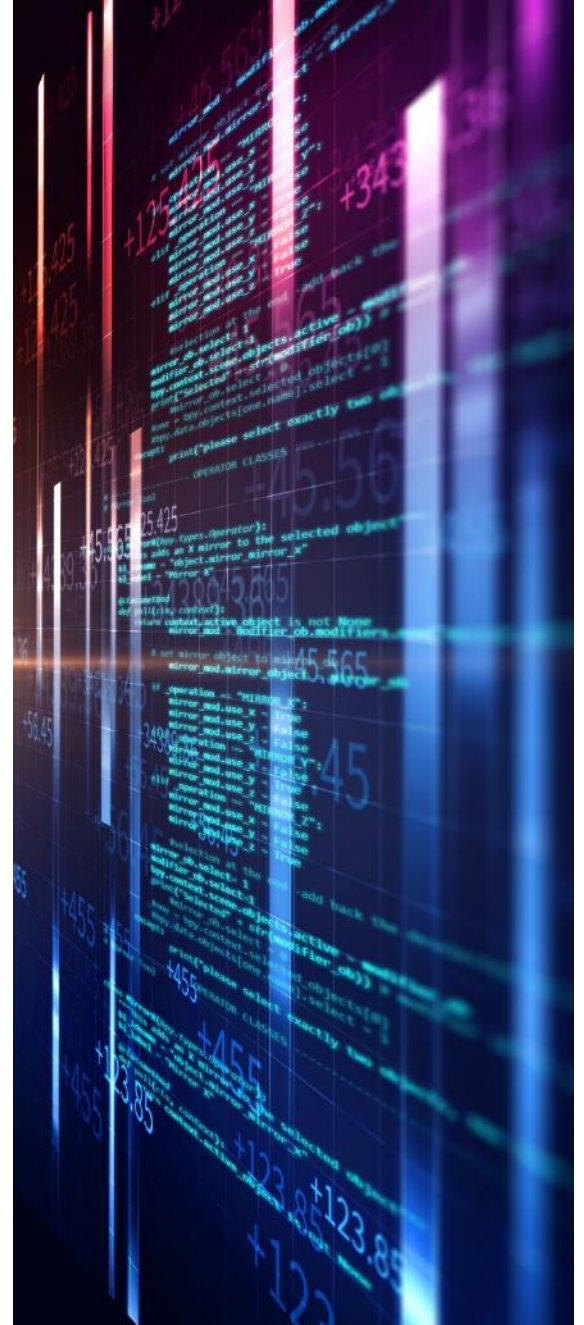


# Outcomes

- Elimination of big overruns &



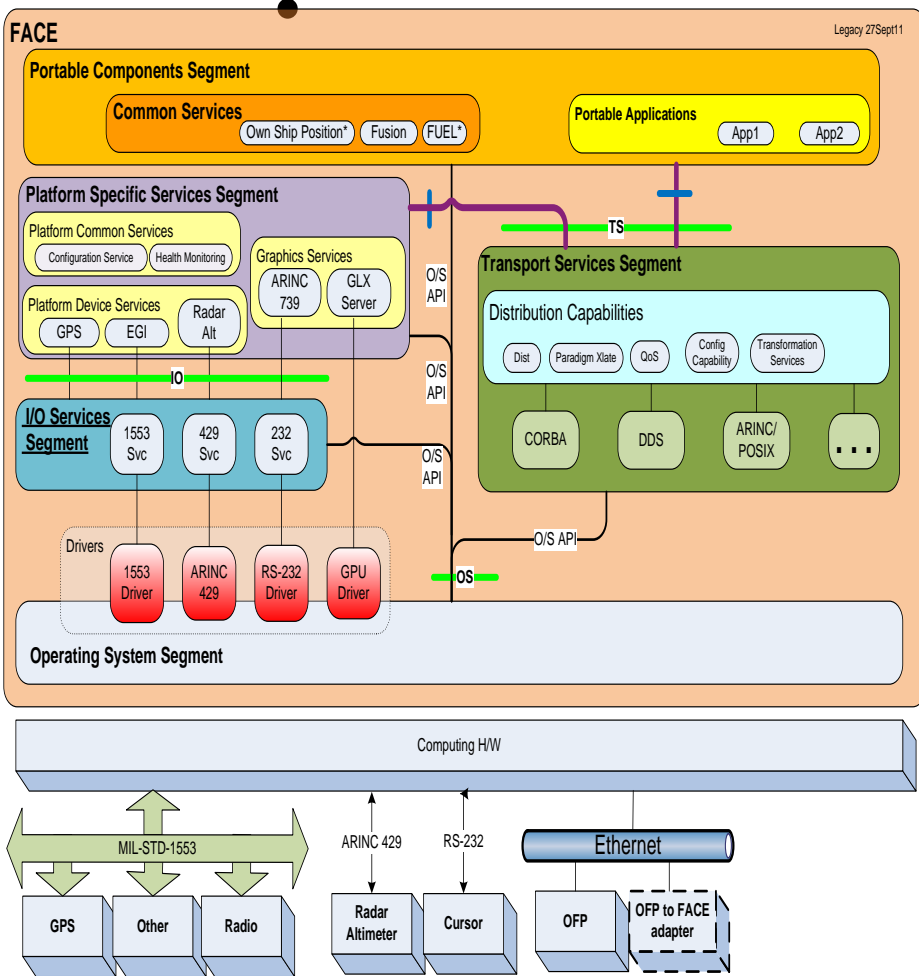
# Questions



# Benefits of Modularity

- Modular
- Business model
- Innovation
- Renumeration
- Competition
- Buy the way it is sold
- Contracting
- Nontraditional suppliers
- IP strategy (good, bad, & ugly)
- Constant discovery of better development methods vs. DoD “Issuances” of approved process
- Incentivize beneficial behavior
- Culture
- Feedback from the field
- Maintenance in the lab
- Cyber testing (white, gray, black boxes)
- Rapid continuous delivery
- Training/acceptance of new functionality
- Robust delivered capability
- Management of deployed capability
- T&E/certification
- Discovery & reaction vs. fixed known requirements

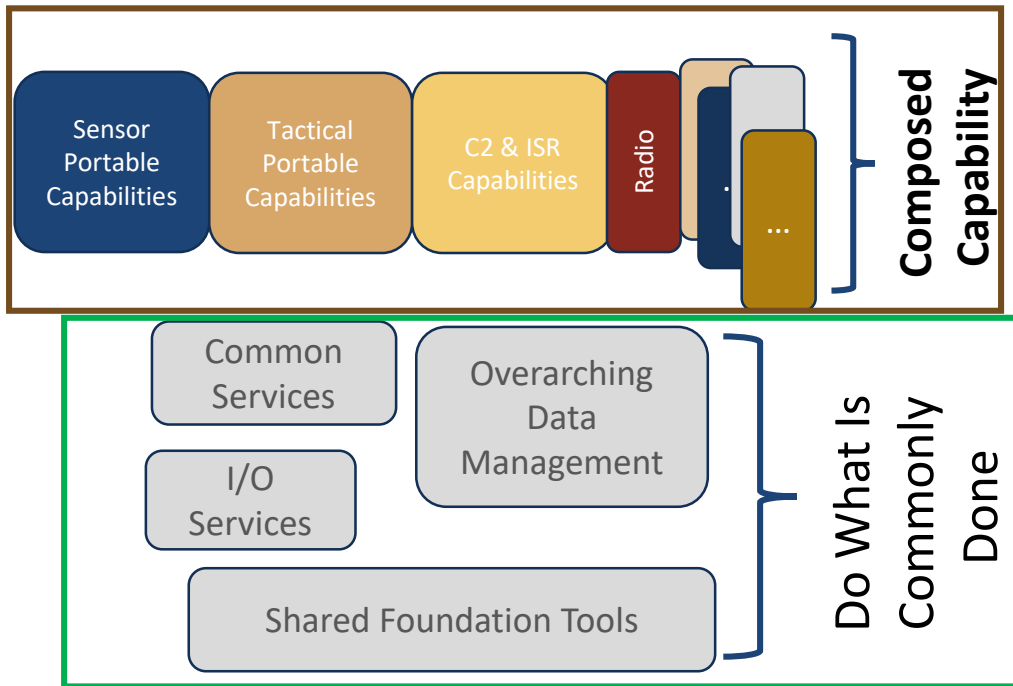
# FACE: A Government-Led, Industry-Supported TRF



- Supported by 80+ defense firms (and growing): LM, GD, Raytheon, NG, Boeing, etc.
- DoD Services-led consortium, supported by an international standards body
- Open technical architecture: participate, vice develop
- Facilitates modular innovation
- Continuously competitive procurement processes
- Modular capability delivery independent of TIs

**Robust, Secure, Interoperable Modular Open System Architectures**





# Rules for Construction Lead to Interoperability

