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July 17 - 22, 2021

Feature-based Product Line Engineering: An Essential Ingredient in Agile Acquisition

Rowland Darbin, David Hartley: General Dynamics

Randy Pitz: Boeing

Bobbi Young, James Teaff: Raytheon

Beth Wilson: INCOSE

Matthew Taylor: ManTech

Paul Clements: BigLever

Overview of presentation

- The authors are all PLE advocates within their respective organizations, which include many of the world's largest defense contractors
- We believe that Feature-based PLE plays, or should play, an important role in many, if not most DoD acquisitions.
- We'll explain why and, more importantly, how Feature-based PLE supports each of the acquisition pathways in the DoD's Adaptive Acquisition Framework (NDIA 2020).

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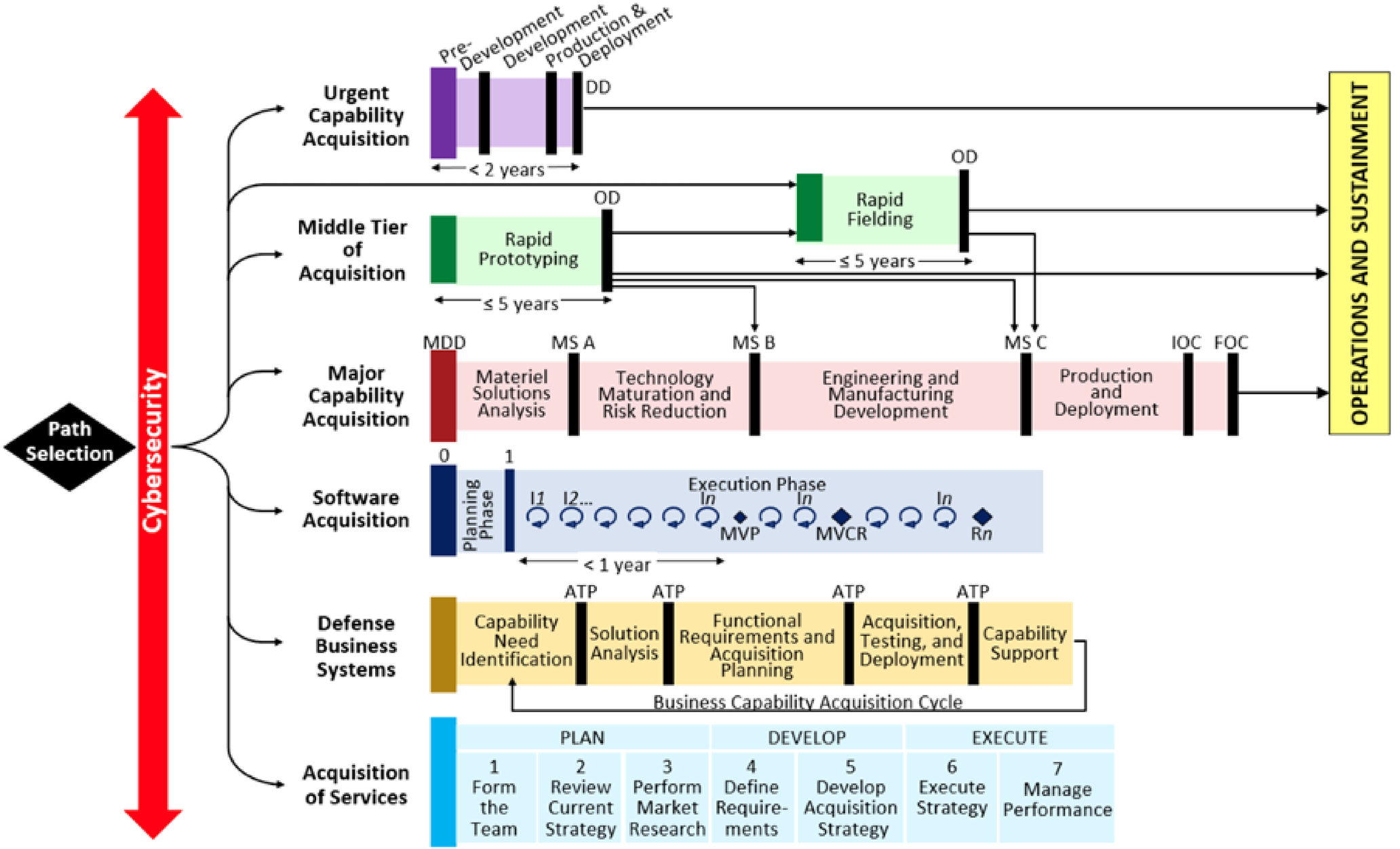
What is the Adaptive Acquisition Framework? (Paul Clements, BigLever)

Overview

- The Adaptive Acquisition Framework (AAF) is a DoD effort to improve the business transactions between the Defense Department and the defense industrial base.
- DoD Instruction 5000.2, titled, Operation of the Adaptive Acquisition Framework was implemented on January 23, 2020.
- It comprises six acquisition “pathways,” plus a Cybersecurity gateway.


Path Selection
Cybersecurity
Urgent Capability Acquisition
Pre-Development
Development
Production & Deployment
DD
< 2 years
Middle Tier of Acquisition
Rapid Prototyping
OD
≤ 5 years
Rapid Fielding
OD
≤ 5 years
Major Capability Acquisition
MDD
MS A
MS B
MS C
IOC
FOC
Materiel Solutions Analysis
Technology Maturation and Risk Reduction
Engineering and Manufacturing Development
Production and Deployment
Software Acquisition
0
1
Planning Phase
Execution Phase
I1
I2...
In
In
In
MVP
MVCR
Rn
< 1 year
Defense Business Systems
ATP
ATP
ATP
ATP
Capability Need Identification
Solution Analysis
Functional Requirements and Acquisition Planning
Acquisition, Testing, and Deployment
Capability Support
Business Capability Acquisition Cycle
Acquisition of Services
PLAN
DEVELOP
EXECUTE
1 Form the Team
2 Review Current Strategy
3 Perform Market Research
4 Define Require-ments
5 Develop Acquisition Strategy
6 Execute Strategy
7 Manage Performance
OPERATIONS AND SUSTAINMENT

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What is Feature-based Product Line Engineering? (Paul Clements, BigLever)

Product Line Engineering (PLE) Defined

ISO 26580 Methods and Tools for Feature-based PLE

Product Line:

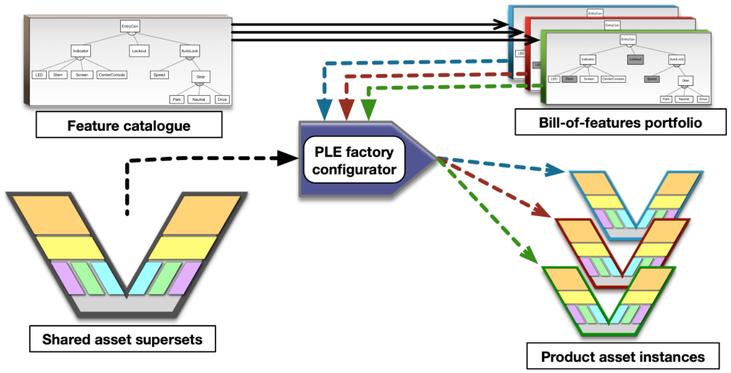
A family of similar products or systems with variations in features.

Product lines are ubiquitous — virtually all products and systems are built as part of a family.

International Organization for Standardization

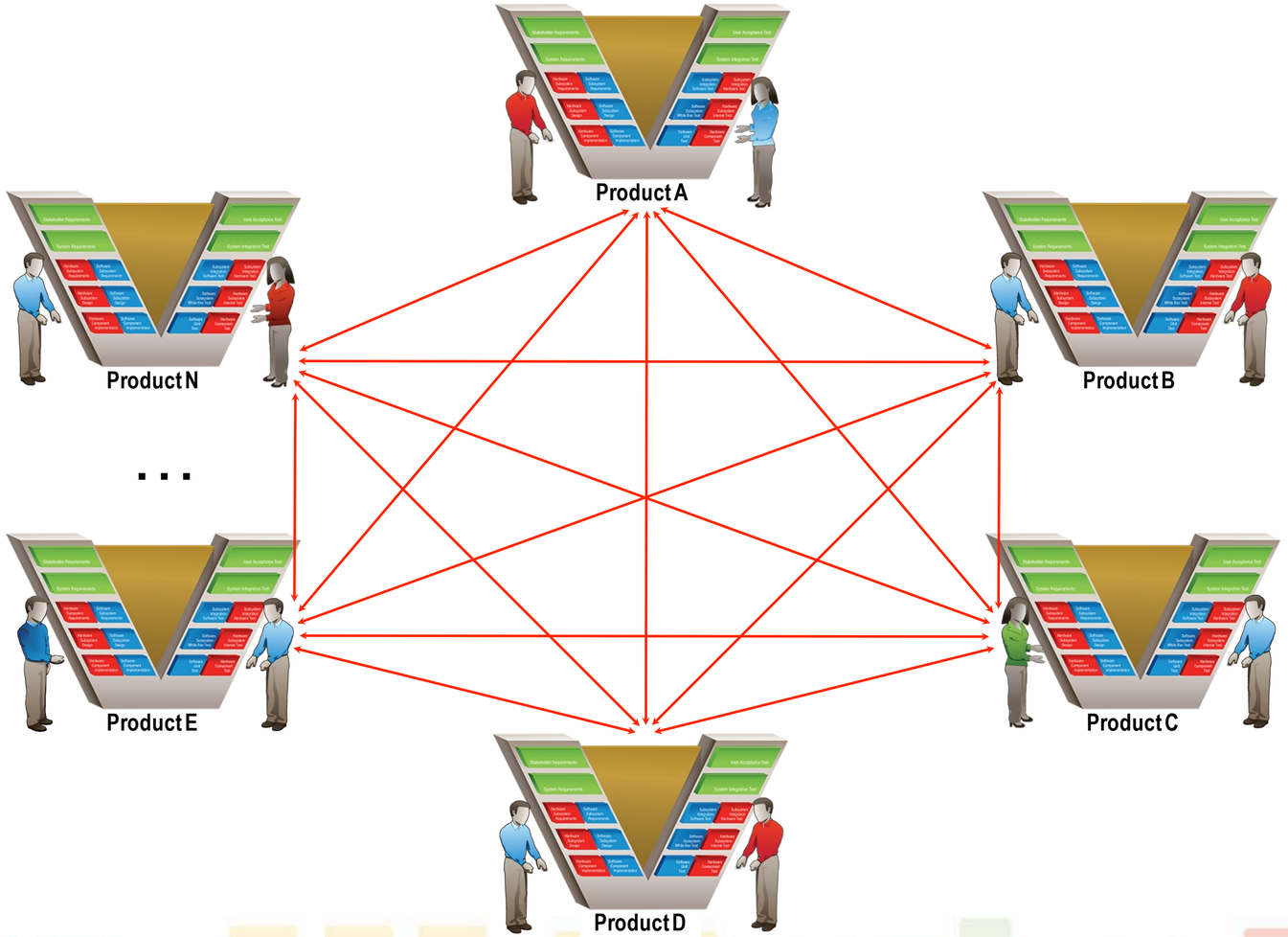
Product Line Engineering:

the engineering of a product line using
shared engineering assets,
a *managed catalog of features*, and
an *automated means of production*…



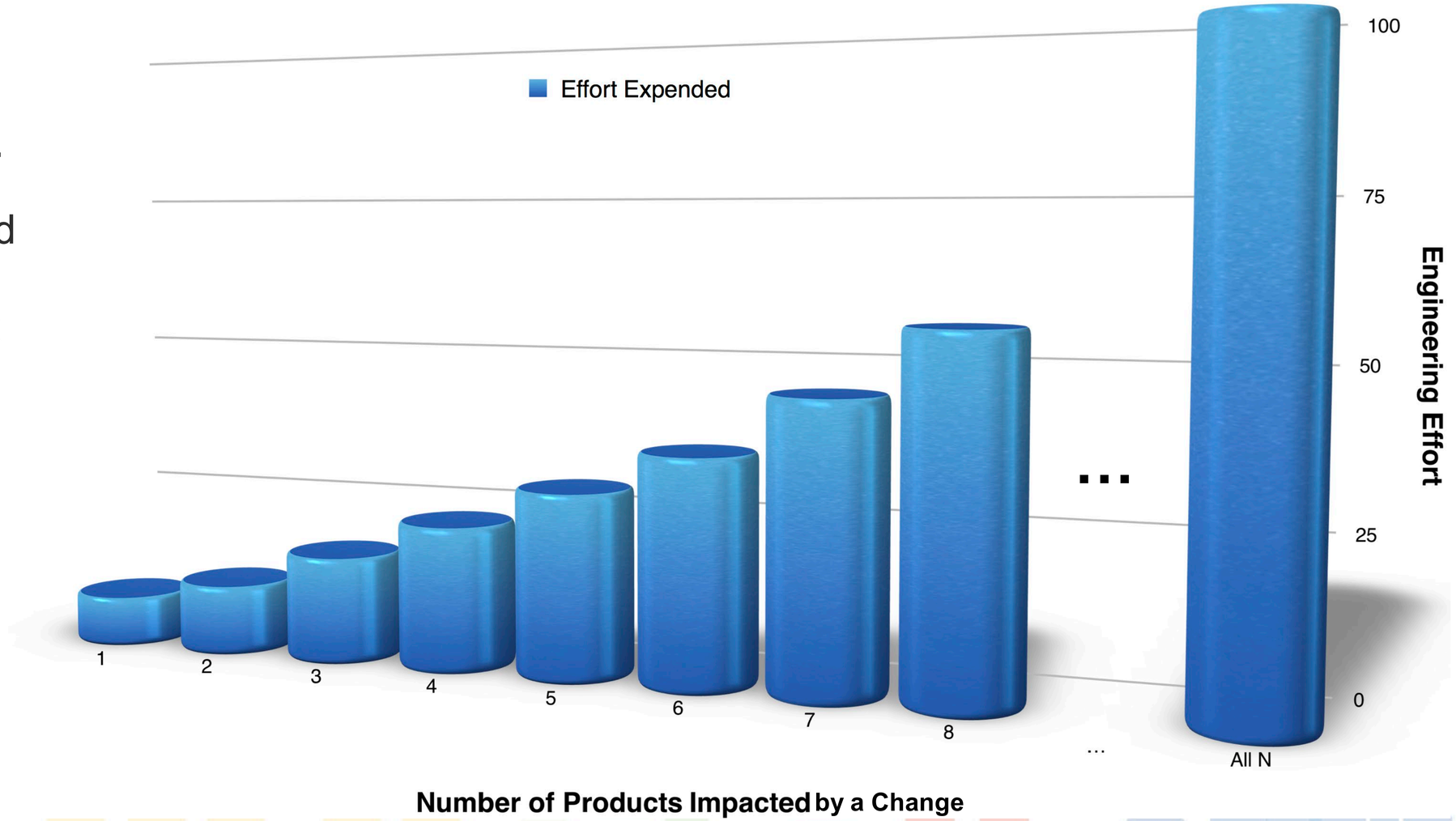
- taking advantage of the **commonality** shared across the family
- efficiently and systematically managing the **variation** among the products or systems

PLE is a move away from the mismatch of point solution engineering — duplication, branch-and-merge, clone-and-own, self-inflicted N^2 complexity

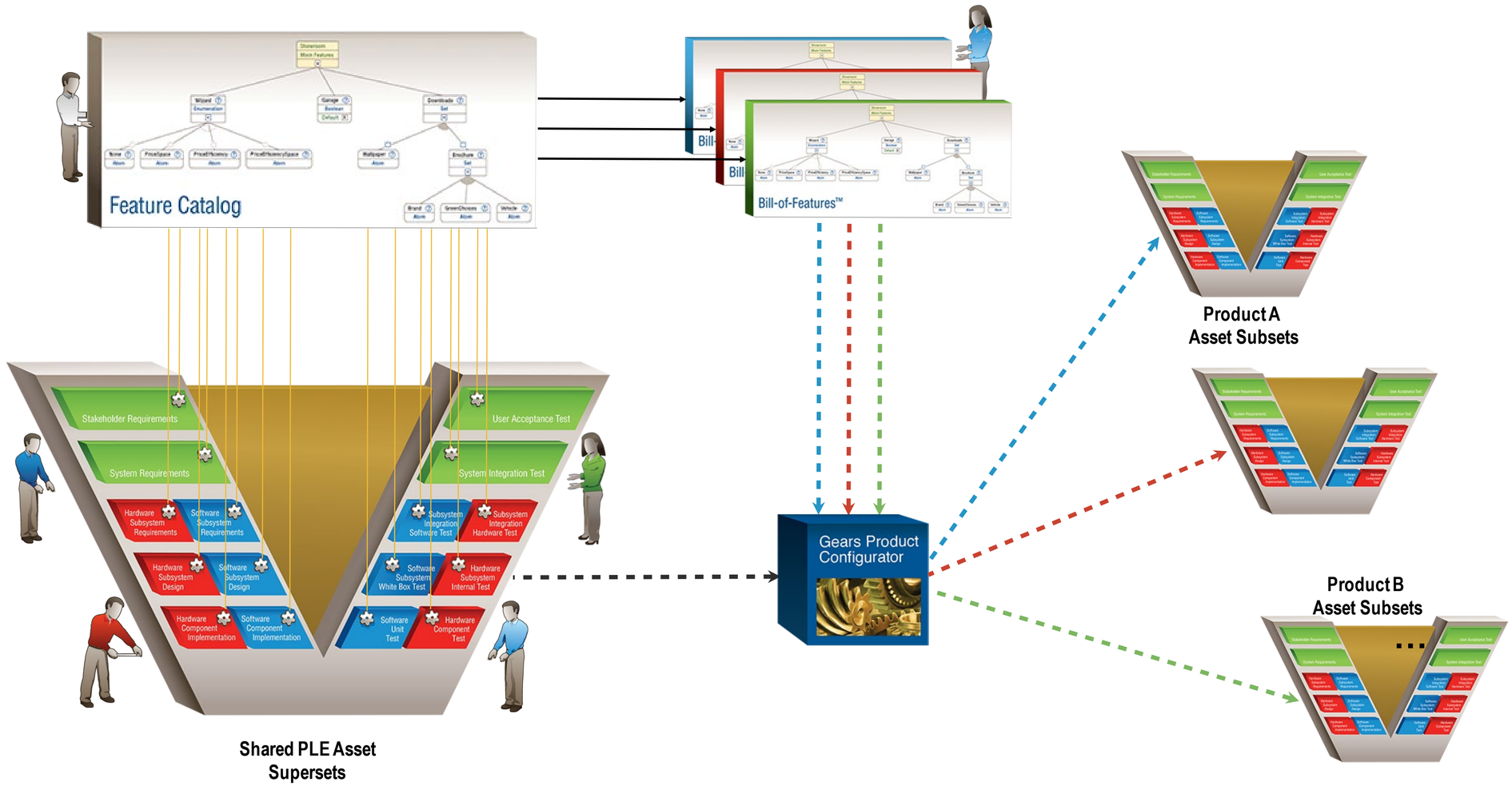


Point Solution Engineering Effort

- Results in low-value, mundane, replicative work.
- Deprives teams of time and energy better spent on high-value innovative work that advances product and business objectives.
- Introduces significant risks of defects, errors, and omissions.



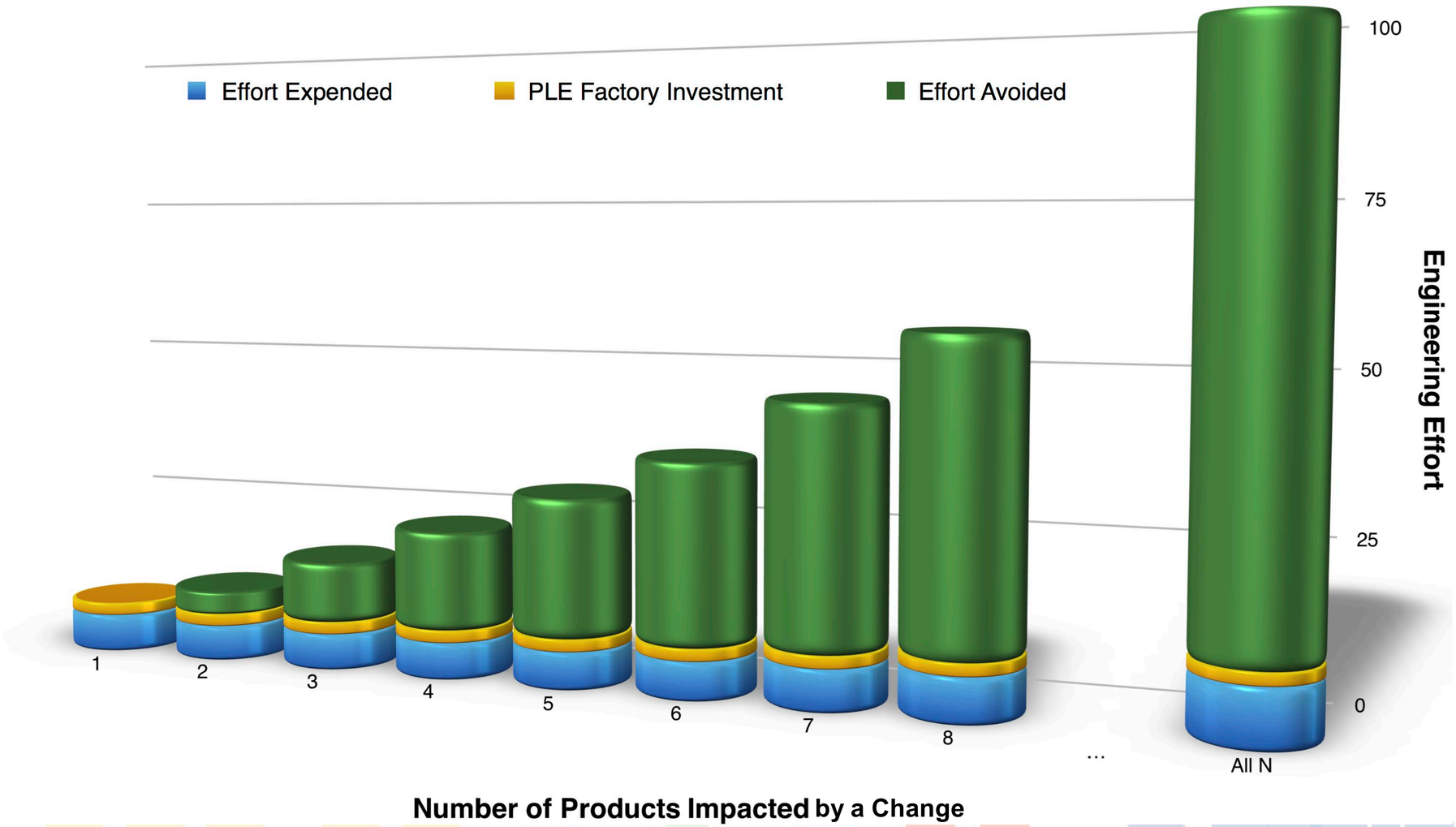
Feature-based PLE Factory



Feature-based PLE Effort Avoidance

Work is done once.

Automation applies the work to all products to which it applies.



Some of the companies applying Feature-based PLE

Boeing, General Dynamics, Lockheed Martin, Northrop Grumman, Raytheon, General Electric Aviation, General Motors, Stellantis (Fiat Chrysler), NetApp, …

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Cybersecurity
(Beth Wilson, INCOSE)

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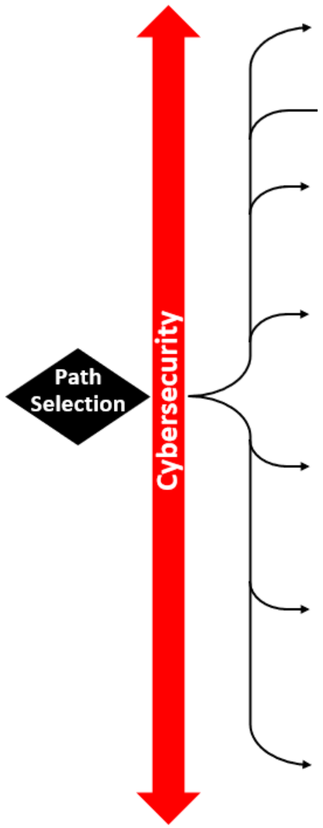
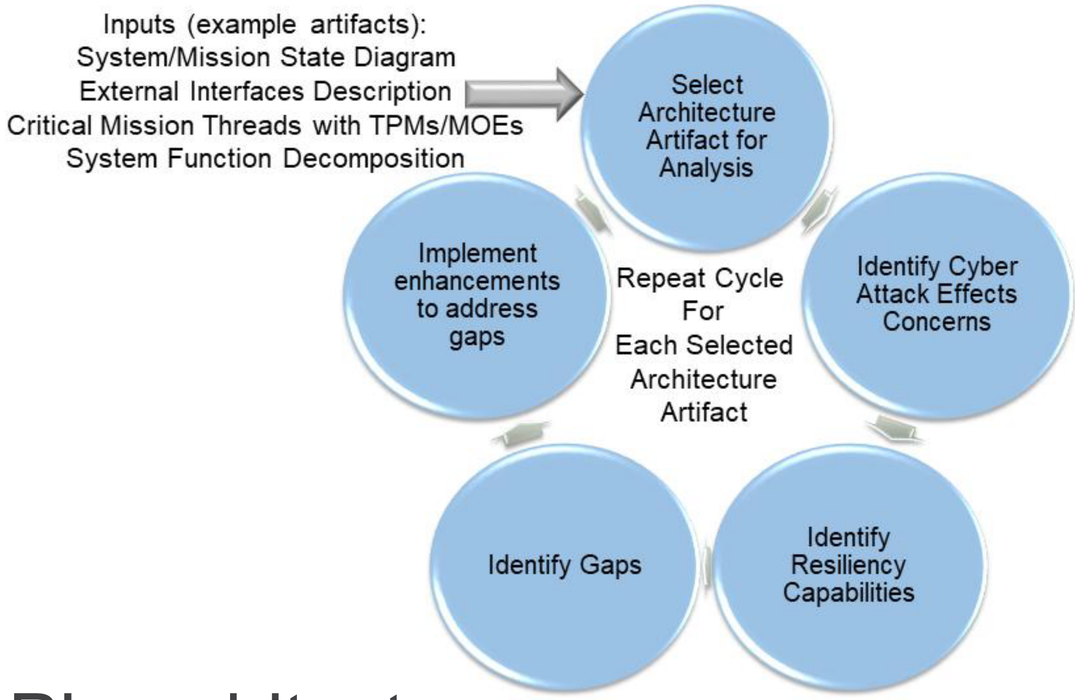
Cybersecurity Gateway



- **Applies to all pathways**
  - Cyberspace defense
  - Operational resiliency



- **PLE/SSE Opportunity**
  - Security work products
  - Design cyber secure/resilient PL architecture
  - Secure the PLE factory
  - Validate instantiated variants

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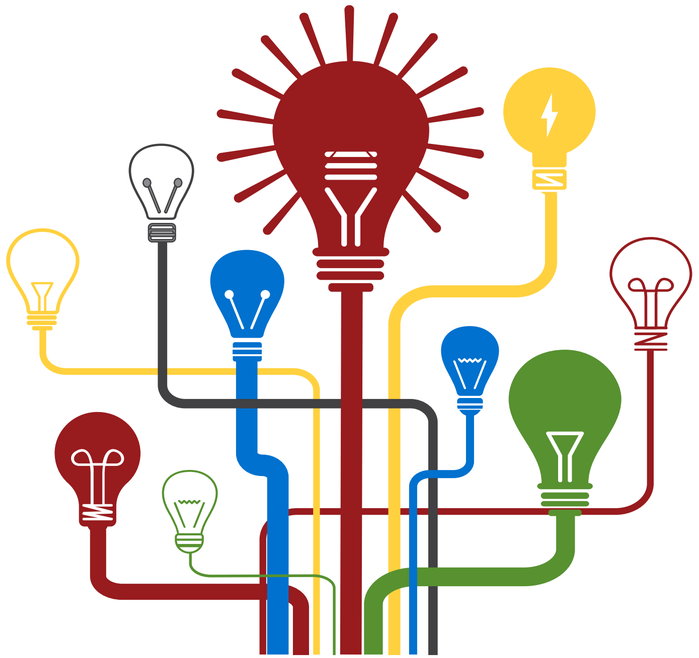
Urgent Capability Acquisition Pathway (James Teaff, Raytheon)

Urgent Capability Acquisition Pathway

- Communication accelerated using product features as the common language
  - Eliminates quality escapes

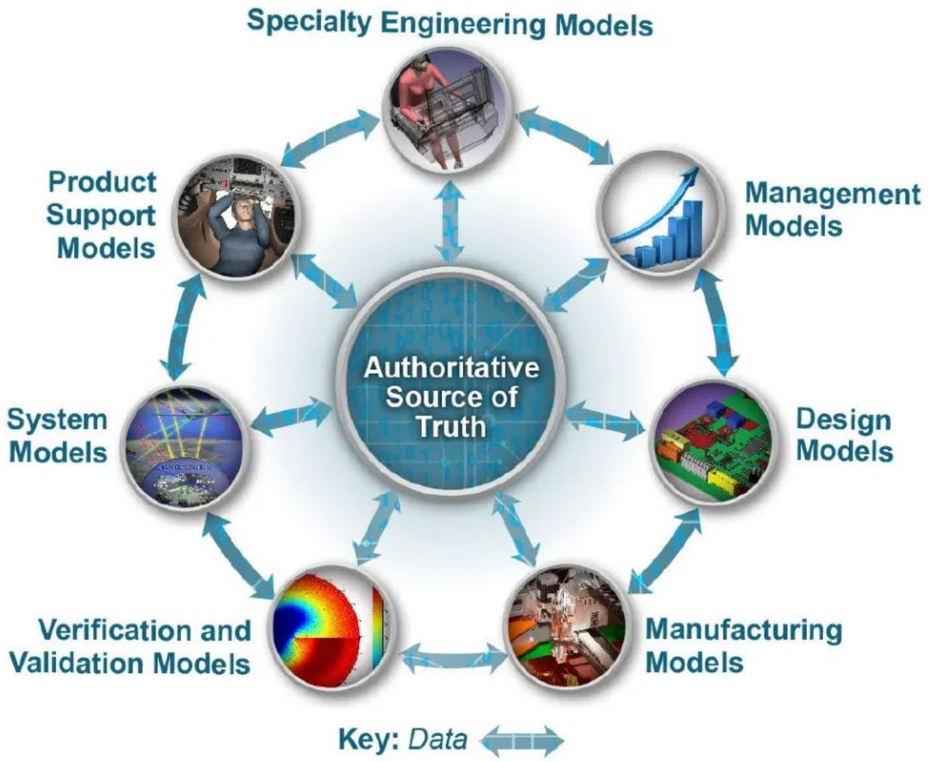
- 80% MVP ~8 weeks
  - Innovation thru adding to field-proven shared asset superset
  - Leverage pre-existing digital thread



- Rapidly adapt to changes in the warfighter's environment
  - From warfighter "I need" to fielded product capability in hours-to-days

- Continuous delivery of value for contract period of performance
  - Operations and sustainment rhythm based on warfighter need

Modular, Composable Products using DE



- Digital Engineering (DE)
- Model-based PLE – Feature model is the authoritative source of truth for product variation across the entire digital thread
- Feature-oriented scope, commonality and variability analysis
- MOSA Open System Architecture conformant

- Variants automatically composed from modular, severable, reusable HW + SW components (Dev*Ops)
- Product rule base (assertions) continuously verify & validate variants
- Removes human-in-the-loop process delays and quality escapes

Feature model is the authoritative source of product variation truth accelerating life cycle activities

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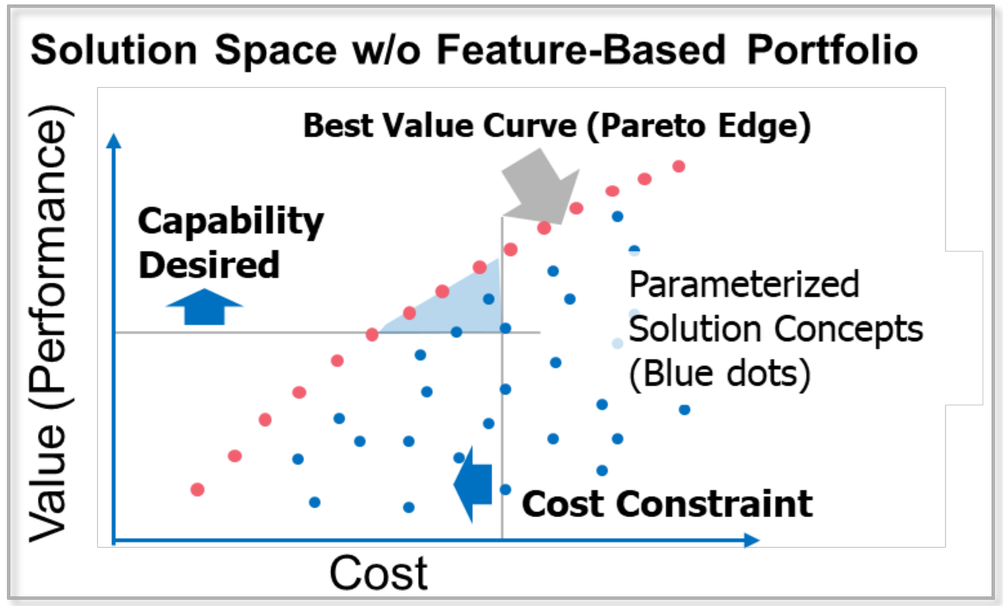
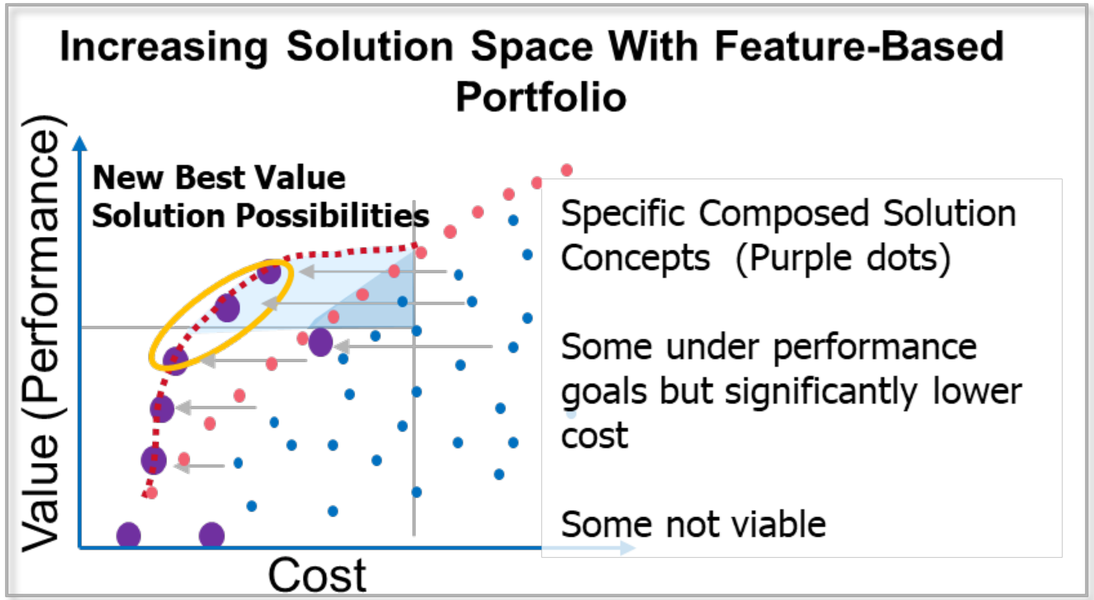
Middle Tier Acquisition Pathway (Bobbi Young, Raytheon)

Middle Tier of Acquisition Pathway

- Development of new capabilities based on ability to rapidly prototype demonstrable solutions
- Identify feasible solution options through proliferation of modular design configurations (purple dots) that fit within the cost and value (performance) curve based on a portfolio of mature technologies
  - Fall on a LOWER cost curve than parametric solutions
  - Performance evaluated in simulations using composed prototype solutions from reusable modular components with purposeful variation

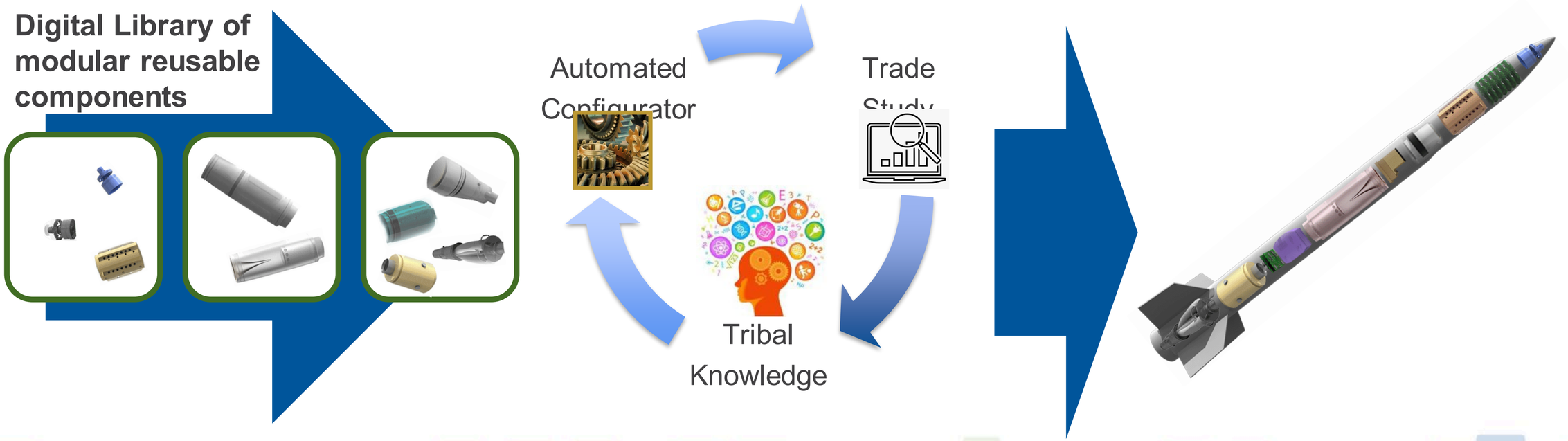




Composing Disruptively-Lower-Cost Solutions

Features, Rules, and Automated Configurator Identifies Trade Analysis Options Providing Input to Performance Simulation Environments

- Feature-based Product Line Engineering approach manages the portfolio of common and variant reusable components
- Features and rules are used to automatically proliferate through the product portfolio design space characteristics
- Feasible design solution prototypes are rapidly identified within a virtual trade space and input into simulation environments



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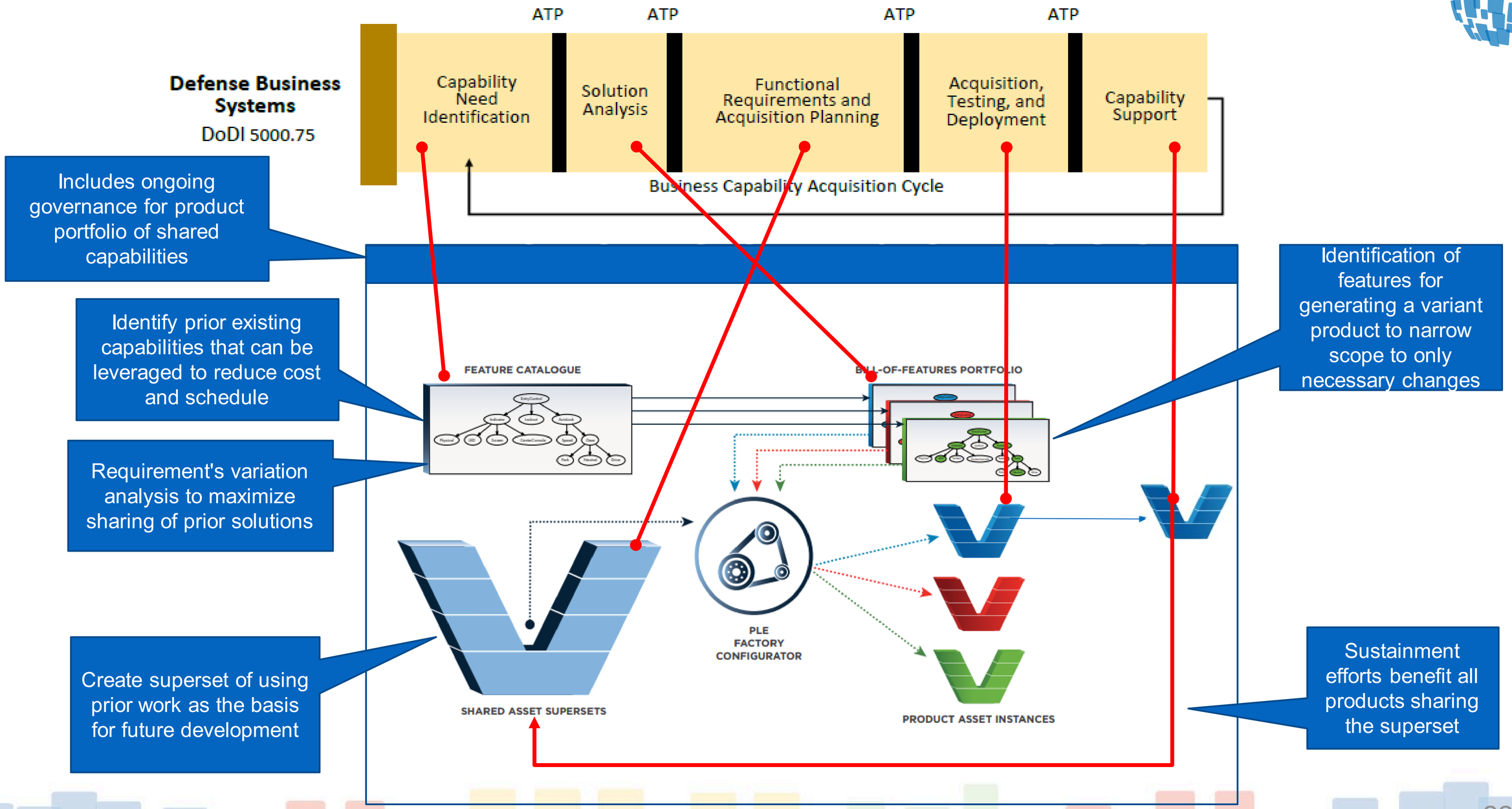
Defense Business Systems and Acquisition of Services Pathways (Rowland Darbin, David Hartley: General Dynamics


Defense Business Systems
DoDI 5000.75
ATP
ATP
ATP
ATP
Capability Need Identification
Solution Analysis
Functional Requirements and Acquisition Planning
Acquisition, Testing, and Deployment
Capability Support
Business Capability Acquisition Cycle
Includes ongoing governance for product portfolio of shared capabilities
Identify prior existing capabilities that can be leveraged to reduce cost and schedule
Requirement's variation analysis to maximize sharing of prior solutions
Create superset of using prior work as the basis for future development
Identification of features for generating a variant product to narrow scope to only necessary changes
Sustainment efforts benefit all products sharing the superset
FEATURE CATALOGUE
BILL-OF-FEATURES PORTFOLIO
PLE FACTORY CONFIGURATOR
SHARED ASSET SUPERSETS
PRODUCT ASSET INSTANCES

Acquisition Cycle Phase	Guidance	PLE Considerations
Capability Need Identification	Capability need is based on the desired end state in a business mission area, the problem(s) preventing it, and the future capabilities required to achieve it.	Create feature model based on known differences. Composition of feature required for new product Bill-of-Features.
Solution Analysis	Future capabilities are based on reengineering the high-level future business processes that will deliver the capabilities.	Identify new requirements that fill the missing need, and tailor existing requirements using variation
Functional Requirements and Acquisition Planning	Describes how the business system will achieve the future business processes.	Share common content from prior efforts, ensure governance address need for shared development teams. New capabilities development can be centralized.
Acquisition, Testing, and Deployment	Detailed fit-gap analysis follows solution selection based on the acquisition strategy. Fit-gap analysis will be based on the known capabilities of the Commercial-Off-the-Shelf/Government-Off-the-Shelf (COTS/GOTS) software in the selected business system solution.	Analysis includes the direction for high level tailoring of the Government-Off-the-Shelf capabilities.
Capability Support	This phase provides support for the business capability, including continued cybersecurity readiness and enduring support for and appropriate upgrades to the business system.	Combine sustainment efforts based on superset capabilities to ensure all teams benefit form the continued development efforts of others in the portfolio.

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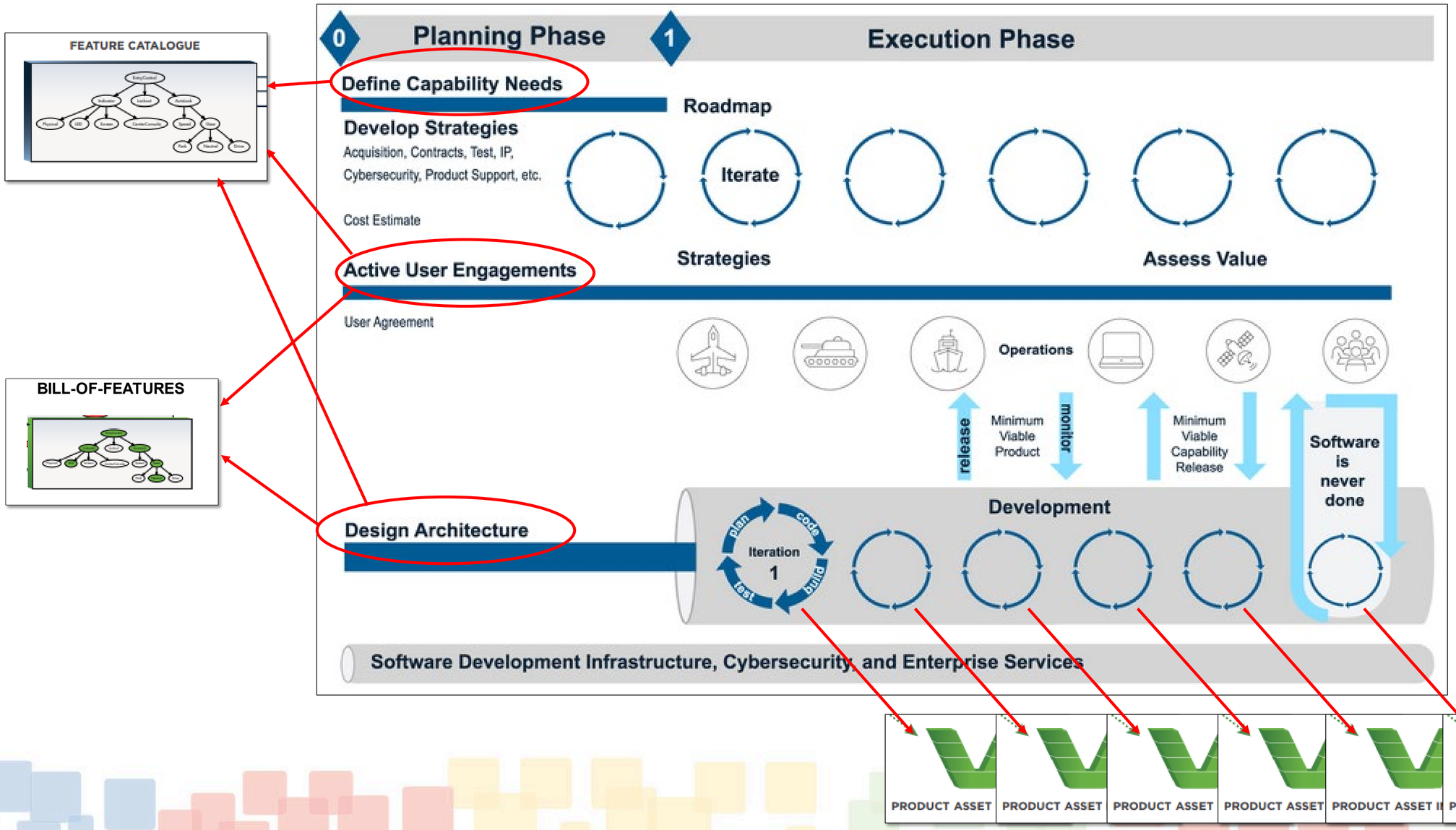
Software Acquisition Pathway (Randy Pitz, Boeing)

Software Acquisition Pathway



IP Strategy Balance

- **Intellectual Property Strategy**
  - Maximum extent delivery of product line superset assets erodes the product line
  - Beneficial private investment into product line optimization may be avoided, increasing costs passed on to the government
  - These forces are at odds when creating products that are more efficiently developed and managed as variations within a common baseline
  - Tension dealing with ownership of IP inside the PLE factory vs. generated instances
- **Potential Solution**
  - Balanced IP considerations enabling Government and Industry partnership success
  - Delivery of generated Product Asset Instances rather than PLE Factory internal IP

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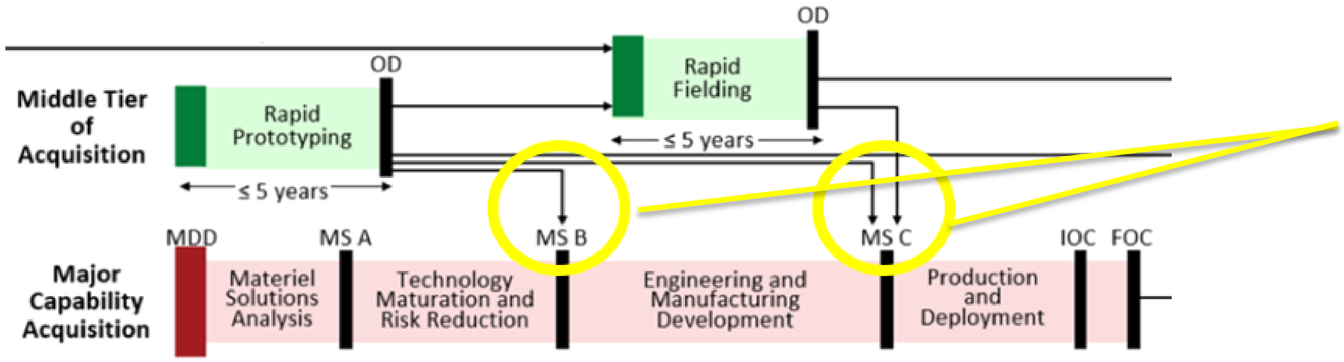
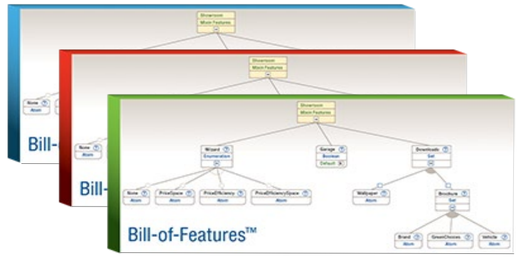
Major Capability Acquisition Pathway (Matthew Taylor, ManTech)

Major Capability Acquisition Pathway



Rapid capability insertion = Desired variation

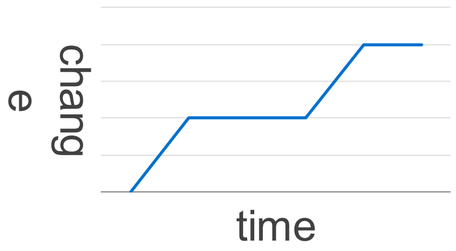
- Approach as deltas to Bill-of-Features Portfolio



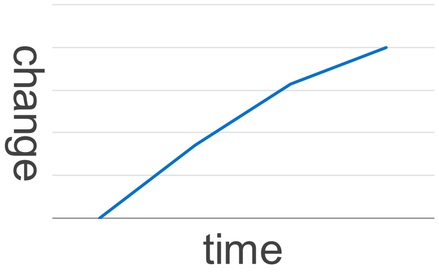
Navigating Change – Major Capability Acquisition

Key Ingredients	Benefits
Agile practices and mindset	Ability to adapt
Composable architecture	Modularity
Open architecture principles	Modifiability
Standards-based interfaces	Interoperability of systems & vendors
Feature-based PLE	**Holistic variation & Bill-of-Feature management**

FROM
Anticipated architecture change



TO
Realized architecture change



Conclusions

- Feature-based PLE has an important role to play in increasing the effectiveness of each of the acquisition pathways of the AAF.

- Questions?

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