WELCOME!

INCOSE Enchantment Chapter Monthly Meeting

We’re glad you’re here.

We respectfully request:

- Mute your audio when you are not speaking
- *6 toggle or in GlobalMeet left-side, your name

Discussion and questions are encouraged!

Put questions in the chat box or unmute yourself to speak up.

Meeting Materials

Slide presentations can be downloaded prior to start of the meeting from the Meeting Materials page of our website:

https://www.incose.org/incose-member-resources/chapters-groups/ChapterSites/enchantment/resources/meeting-materials

If recording is authorized by speaker, the video will be posted at the link above within 24 hours.

SEP Training

CSEP Courses by *Certification Training International:*

CTI currently is offering online course offerings, see https://certificationtraining-int.com/incose-sep-exam-prep-course/

Our chapter has two SEP mentors:

Ann Hodges alhodge@sandia.gov

Heidi Hahn drsquirt@outlook.com

Upcoming meetings

- January 13, 2021: David Long – Schema and Metamodels and Ontologies – Oh My!
- February 10, 2021: Gan Wang – Implementing a Model-Based Digital Engineering Enterprise for a Defense System Integrator
- March 10, 2021: Dr. Ron Carson – Perspectives on the Boeing 737MAX Maneuvering Characteristics Augmentation System (MCAS)

Introductions

- Please type your name, position, and organization in the Chat window

Photo by Adam Solomon on Unsplash

Survey

The link for the online survey for this meeting is

- www.surveymonkey.com/r/2020_12_MeetingEval

Your feedback is important!

Enchantment Chapter Monthly Meeting

4:45pm – 6:00pm MT

Patterns for Success in the Adoption and Execution of Feature-Based Product Line Engineering

Abstract: Systems and Software Product Line Engineering (PLE) is a general approach to engineer a portfolio of related products in an efficient manner, taking advantage of the products' similarities while respecting and managing their differences. The approach manages a product portfolio as a single entity, as opposed to a multitude of separate products. Numerous resources describe the organizational benefits associated with incorporating PLE techniques and tools. Feature-based System and Software Product Line Engineering is a specific form of PLE that is powered by commercial off-the-shelf automation, fully defined processes, and a formal language of variation based on features. Many case studies show the efficacy of Feature-based PLE and the improvements in cost, schedule, and quality that can come with it. This talk summarizes a paper from INCOSE's 2020 International Symposium, in which practitioners from four of world's six largest defense companies highlight their experience with the practices that enable and inhibit success with this powerful engineering discipline.

Download recording from the Library at www.incose.org/enchantment

NOTE: This meeting will be recorded

Speaker Bios

Dr. Paul Clements is Vice President of Customer Success with BigLever Software, a leading product line engineering company. His job is to help organizations gain the maximum benefits available from PLE, in real-world settings. Previously he was a senior member of the technical staff at Carnegie Mellon University's Software Engineering Institute, where he worked from 1994 through 2011 leading or co-leading projects in product line engineering and software architecture documentation and analysis. While there, he co-wrote the SEI's first product line case study, was co-creator of the SEI Framework for Product Line Practice, was an author of the book *Software Product Lines: Practices and Patterns*, and helped to create the SIMPLE modeling language for product line economics. In addition to his work in product line engineering, Clements is the co-author of seven editions of three practitioner-oriented books about software architecture, as well as approximately one hundred papers on architecture and product line engineering. He received a B.S. in mathematical sciences in 1977, and a M.S. in computer science in 1980, both from the University of North Carolina at Chapel Hill. He received a Ph.D. in computer sciences from the University of Texas at Austin in 1994.

David Hartley is a Senior Advanced Software Engineer and Product Owner for the General Dynamics Missions Systems Product Line Engineering Center of Excellence. He started his career at FedEx where he held many roles such as Software Engineer, Technical Advisor and Enterprise Application Architect. In addition to working at FedEx, David spent some time doing consulting work for companies such as Citibank and Blue Cross Blue Shield of Florida. David has been at GD Missions Systems for over 3 years working on the Pando Project, which is a corporate initiative to promote and implement Product Line Engineering (PLE). As the product owner for the PLE Center of Excellence (CoE), David leads an agile team whose mission is to maintain and execute the governance and processes necessary to execute PLE across GDMS. The CoE prepares PLE-ready product teams who understand PLE principles, use PLE tools, establish governance, become self-sufficient and assist others to adopt PLE. David holds a Bachelor of Science in Computer Science from Florida State University and a Master of Business Administration from the University of Central Florida.

Patterns for Success in the Adoption and Execution of Feature-based Product Line Engineering: A Report from Practitioners

30th Annual INCOSE international symposium
Cape Town, South Africa
July 18 - 23, 2020

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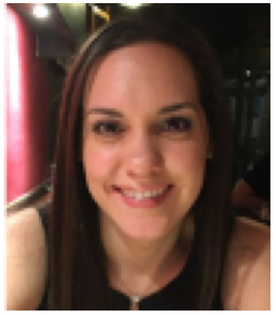

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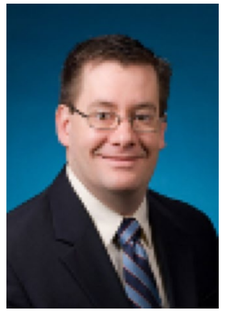

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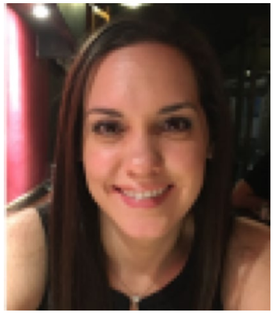

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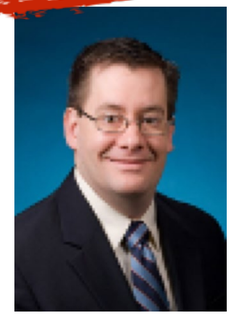

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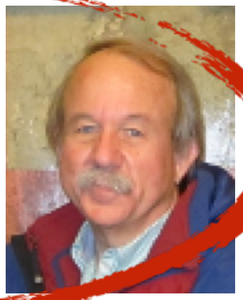

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Presentation Overview

- Feature-based Product Line Engineering is an engineering discipline growing in widespread use
  - Subject of Draft International Standard ISO/IEC 26580
- Authors include PLE champions from four major A&D companies
  - Lockheed Martin
  - Boeing
  - General Dynamics
  - Raytheon
- This is an experience paper reflecting these champions' experience in PLE adoption
  - Patterns of technical success
  - Patterns of organizational success

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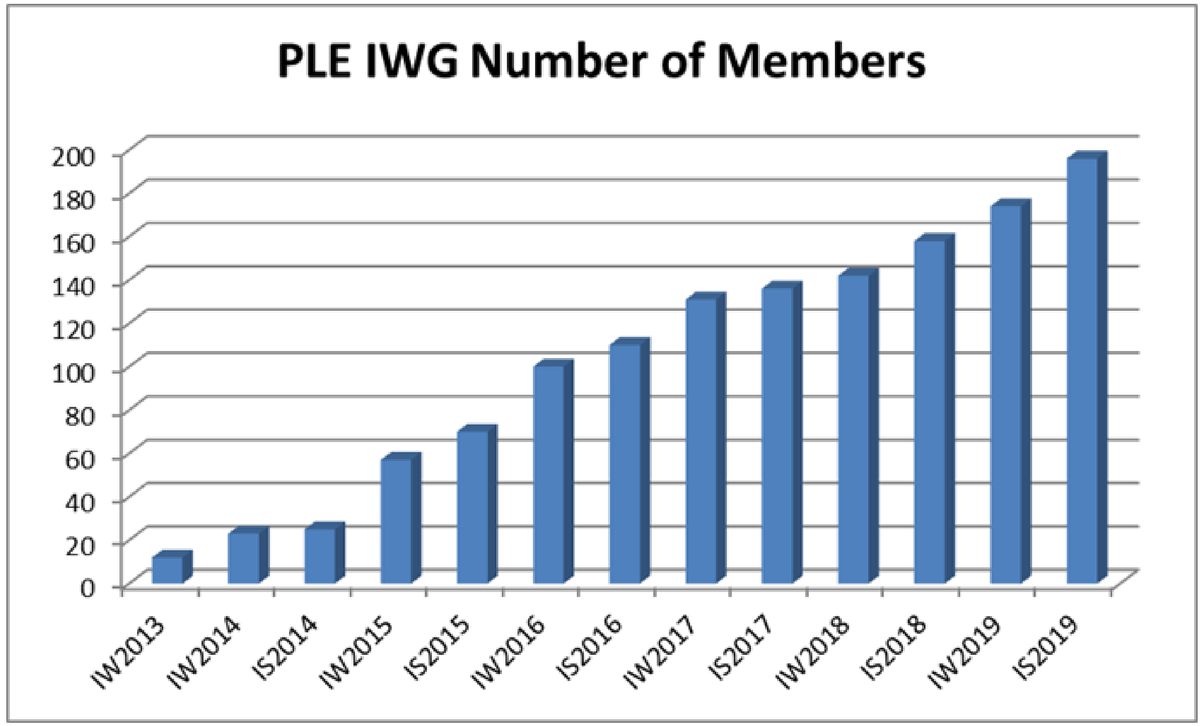
Product Line Engineering Working Group

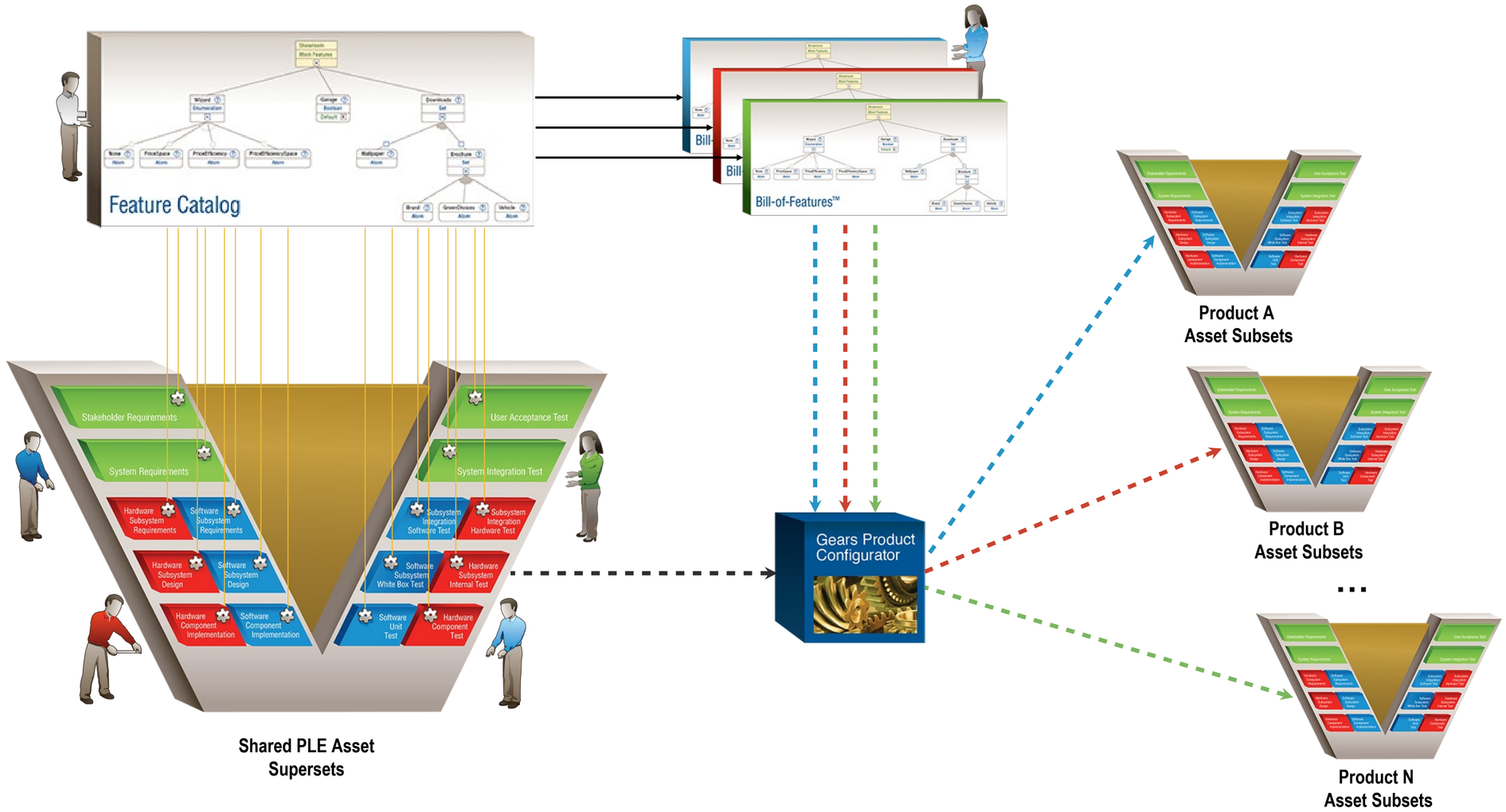
- Mission
  - Promote Product Line Engineering and related Systems Engineering best practices
  - Coordinate activities around PLE at INCOSE level and share results
- Objectives
  - Help our members acquire know-how
  - Provide guidelines to establish and grow PLE in organizations



Product Line Engineering Working Group

- ISO 26580: Methods and Tools for the Feature-based Approach to Systems and Software Product Line Engineering
- IW 2019 – Working Group Award for Sustained Performance
- IW 2020 – Product of the Year
  - *Feature-based Systems and Software Product Line Engineering: A Primer*
- Upcoming *Insight* PLE-themed issues
  - September 2020: “Systems Security and Product Line Engineering”
  - December 2020: “PLE In Context”

Feature-based Product Line Engineering



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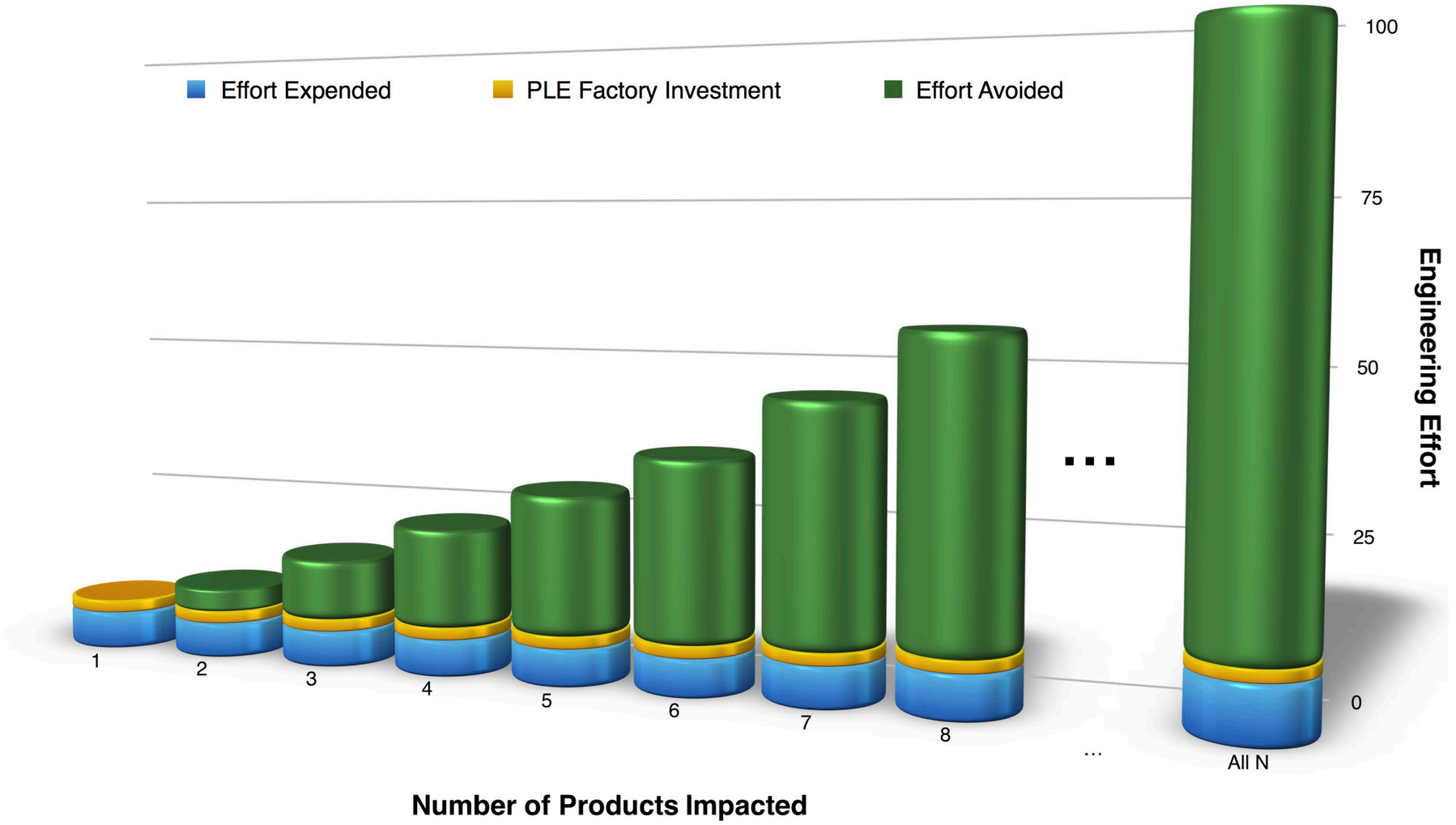
Feature-based PLE Effort Avoidance



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LOCKHEED MARTIN	GENERAL DYNAMICS	General Motors	NetApp	HomeAway	
World's #1 Defense Contractor	**World's #3 Defense Contractor**	**World Leading Automotive Manufacturer**	**World's #2 Data Storage Provider**	**World Leader in Online Vacation Property Rentals**	**World Leading Aviation Supplier**
AEGIS Weapon System	Live Training Transformation: US Army, Air Force, Marines	Largest, most complex product line comprising over 10,000,000 instances per year	High-end server storage systems	E-commerce websites hosted in over 200 countries worldwide	Whole-aircraft avionics product line
High cost of old approach threatened loss of entire contract	Innovative low-cost solution essential to win/keep major contract	Vehicles taking too long to engineer: expensive, error-prone processes	Unable to accommodate rapid market growth	Broad site variation around the world; needed to go live ASAP	High cost of product certification
Feature-based Product Line Engineering Results with BigLever					
Over 100 ship deployments: $55 million saved annually	**Over 300 training range deployments: $900 million saved over 12 years**	**Hundreds to thousands of man-years annually; tens to hundreds of millions of dollars annually for one asset type alone**	**2x-5x improvements in scalability, productivity, time-to-market, and product quality**	**First product went live in 60 days**	**8:1 improvement in time to produce certification documents**

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Lockheed Martin: Powerful Governance

- Product line: AEGIS Weapon System (AWS)
  - Heart of AEGIS Combat System: Protects assets from airborne attack by launching missiles to neutralize threats
  - Deployed on >100 naval vessels plus land-based sites
- Feature-based PLE
  - > 100,000 requirements, > 10M SLOC
  - Annual savings of $47 million from PLE
  - “Develop once; deploy many times”
- Key stakeholders
  - U.S. Navy
  - U.S. Department of Homeland Security (Coast Guard cutter)
  - Missile Defense Agency

- Governance: The practice by which the product line is managed and controlled

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Lockheed Martin: Powerful Governance

- Internal governance: Program planning and program execution
  - Weekly meetings to monitor and manage PLE Factory execution through all stages of development
- External (customer-oriented) governance
  - Necessary to coordinate multiple contracts, different lines of funding, and competing resource needs
  - Technical: Joint Engineering Review Team (JERT)
    - Co-chaired by lead system engineers from the government, with technical representation by all product users
    - **Provides guidance to the developer in all technical matters impacting more than one program.**
    - Establishes three avenues for code development, to manage risk to programs in different stages of deployment
  - Programmatic: Joint Program Management Team (JPMT)
    - Government co-chairs and representation by all product users
    - Tactical decision maker for all cross-program issues. **Renders schedule and funding decisions. Applies programmatic considerations to JERT recommendations** and turn those recommendations into decisions.
  - Strategic: Major Program Manager Board
    - Chaired by 3 O-6 (Captain) program mangers. **Sets future baseline content and strategic direction.**
    - Adjudicates issues unresolved by JPMT. Reports directly to its members' respective Admirals.

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Lockheed Martin: Powerful Governance

- Summary: Three levels of external governance (technical, programmatic, strategic) for a large multiple-customer contract-based product line
- The external governance was codified in an Instruction (the Navy equivalent of a policy directive) signed by the Program Executive Office Admiral.
- This act represents the strongest possible endorsement of the governance structures and policies.

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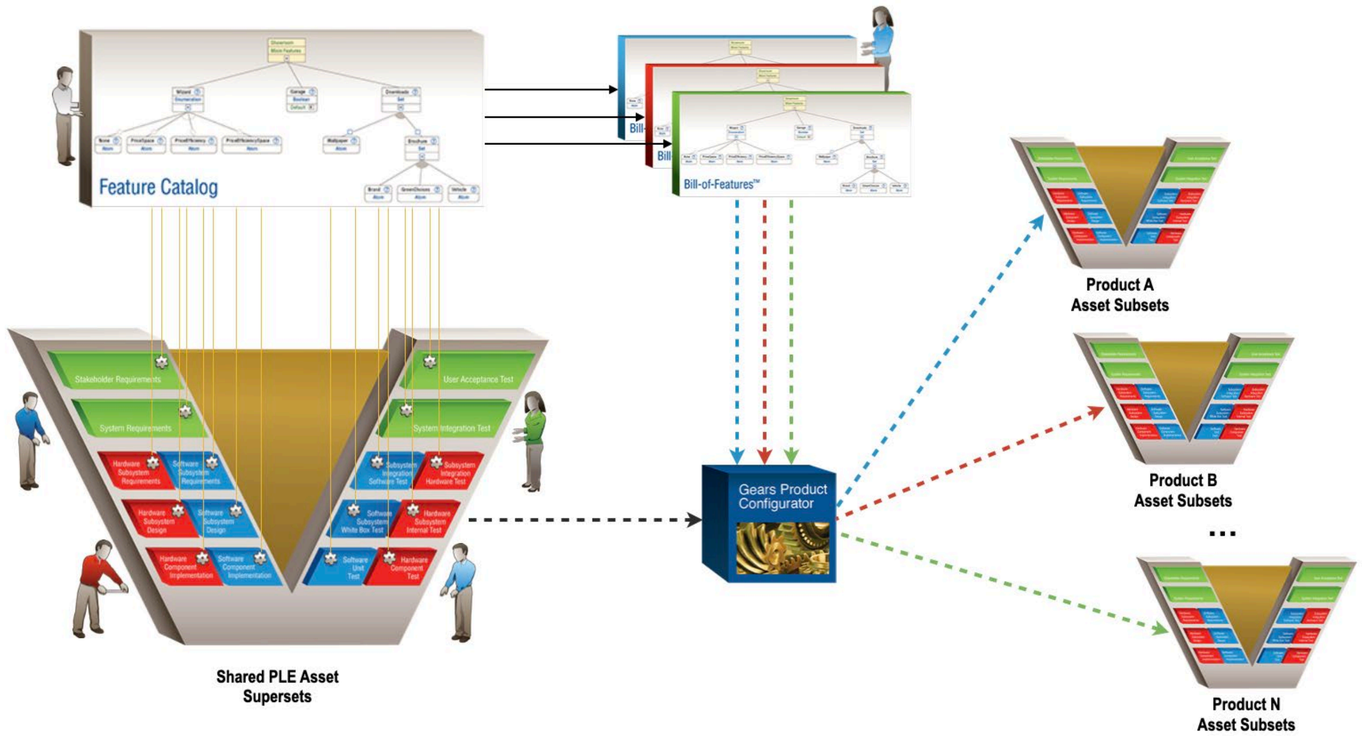
Boeing: The Right Organizational Structure

- PLE Factory is an organizational blueprint, not just a workflow
- Development happens inside the factory, not on the products
- The factory must be staffed and managed to operate efficiently



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Boeing: The Right Organizational Structure

- Best practices for a matrix organization
  - **Process harmonization**
    - Ideally an organization adopting PLE would make use of common processes,
    - When retrofitting PLE into a multi-program organization, that may be hard to attain
    - Apply PLE to the process documentation itself until true harmonization can be achieved
    - Form a dedicated team to support process development, variability, maintenance, and process CM
  - **Beware "vanity reporting"** (asking for the same data in different, custom formats)
  - **Beware meeting overload:** Ensure meetings bring true value.
    - Balance between requiring program representatives to attend product line team meetings and having product line teams support program meetings.
  - **Ensure a disciplined funding policy** for deciding which program pay (how much) for which work
  - **Role clarity:** Have well-defined roles in the organization with clear responsibilities and authority.
    - This will help avoid challenges from change impact assessment and adjudication.

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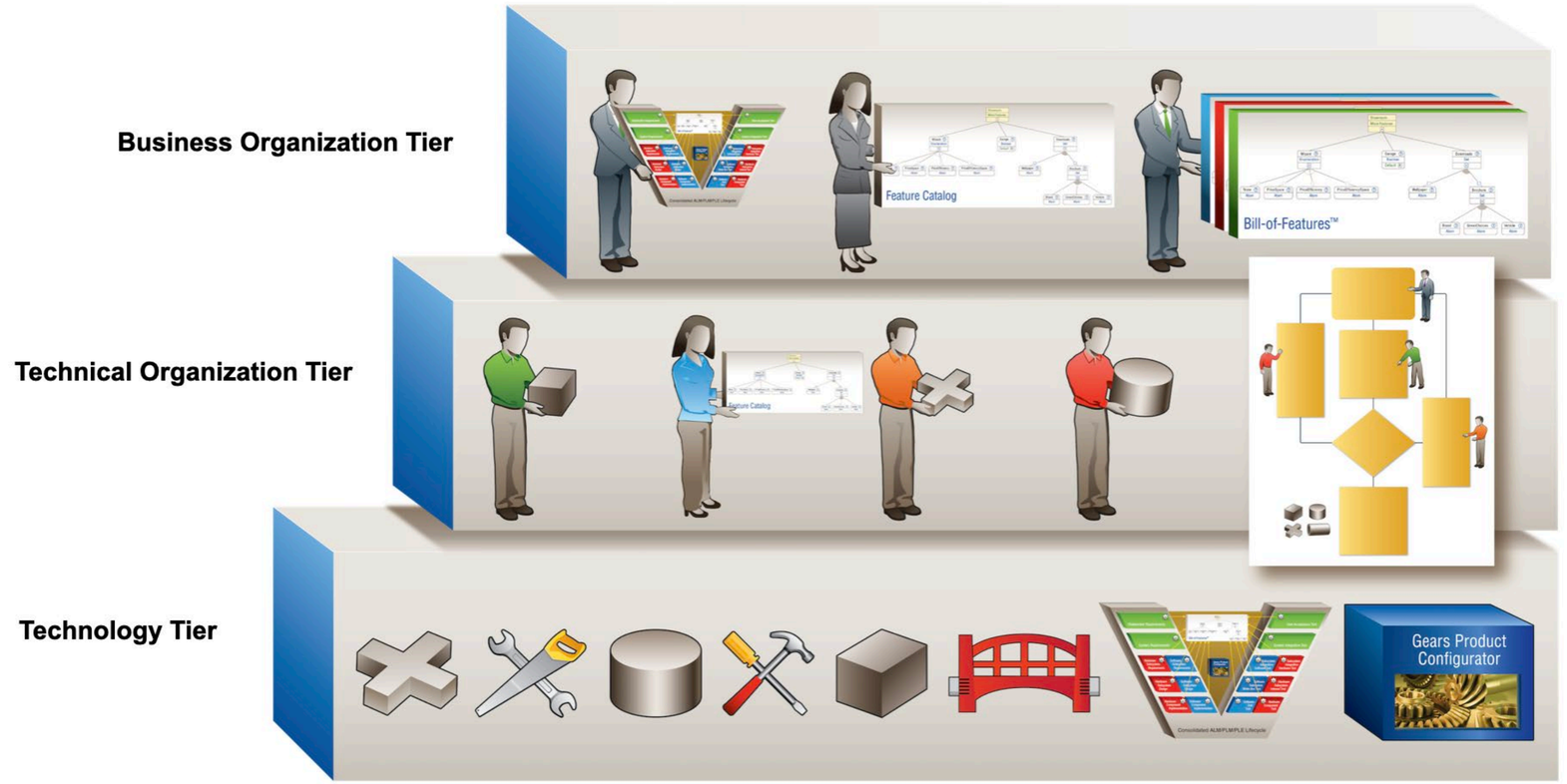
Raytheon: Carefully Planned Adoption

- Reorganizing to establish and operate a PLE Factory takes effort.
- Companies that expect immediate ROI will shut down the PLE adoption before positive results can be obtained.
- Provide incremental return on incremental investment, so that at every stage the adoption is providing positive value
- Recognize the different parts of an organization that must work together to ensure the successful establishment and operation of the PLE Factory.
  - Engage all levels



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Raytheon: Carefully Planned Adoption

- Artifacts to guide the transition to PLE
  - A Living Business Plan owned by mission area leaders; this establishes precise need, importance, urgency, and vision for using PLE. It provides the over-arching vision for the organization's transition to PLE
  - A product line Governance Concept of Operations (ConOps), executed by PLE Factory management; this is the set of processes for the day-to-day execution of PLE practices. The Governance ConOps establishes the tailored governance that will realize the Living Business Plan
  - An incremental plan for creating, staffing, and operating the PLE Factory over time, known as a PLE Spiral Adoption Plan. This plan defines the path to achieve the transition from current state operations to PLE-based operations as described in the Living Business Plan.
- The Guiding Coalition is a key factor for successful PLE incorporation.
  - Group of leaders across all three tiers that are empowered to quickly make decision according to the team's decision making framework; and to continuously remove roadblocks for the product line teams.
- This approach provides a methodical, incremental roadmap to a success roll-out of PLE that will provide positive returns at every step along the way.

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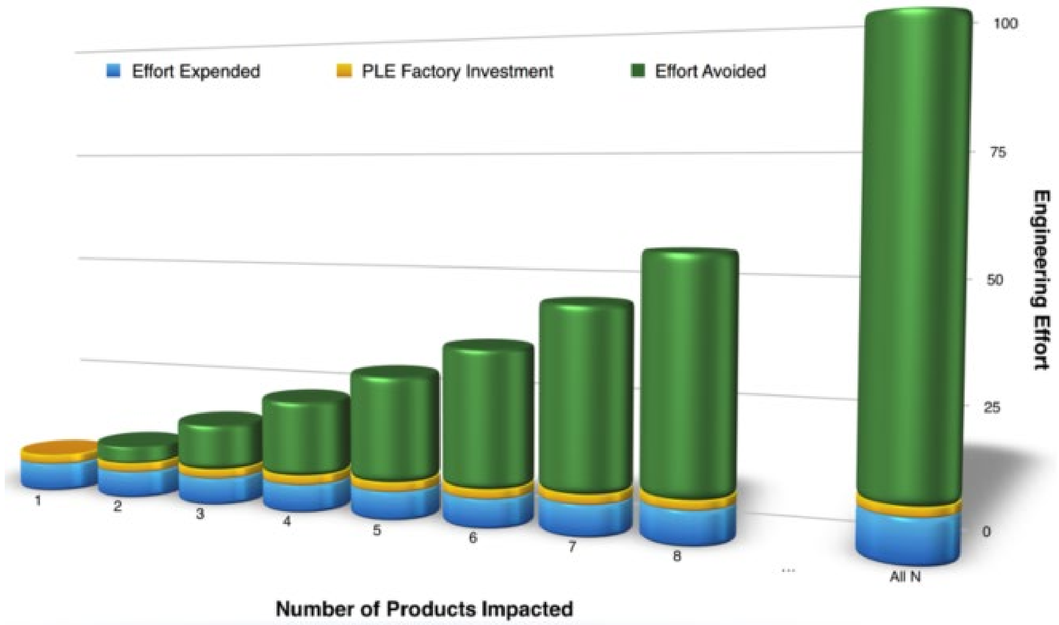
General Dynamics Mission Systems: Measuring Success

- No one would be doing PLE if there wasn't a compelling and significant value proposition.
- The Goal: Eliminating the duplication of "Content" eliminates the work need to maintain that content.
- Drive change by providing <u>evidence</u> of the Benefits
- Benefits of PLE
  - Sharing is faster
  - Work is done more efficiently
  - Costs are lower
  - Quality is higher



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General Dynamics Mission Systems: Measuring Success

- Change effectivity: the scope of applicability exerted by a single change in the product line
- Cost avoided: the measurement of cost avoided with the approach
  - Cost Avoided = (Change Cost)Change Effectivity - (Change Cost)
  - where Change Cost = # of changes * cost per change
- Shared asset utilization
- Product line health
  - Production line metrics
  - Assertions
  - Guidelines
  - Process deviations

Shared Asset Utilization			
Asset	**Superset**	**Production Capability**	**Commonality**
Software	# SLOC	# products, # SLOC	97.5%
Requirements	# modules	# products, # CDRLs	97.0%
Network Configuration	# SLOC	# products, # SLOC	94.7%
Test Procedures	# modules	# products, # CDRLs	96.3%
Training Documentation	# pages	# pages, # manuals	85.5%

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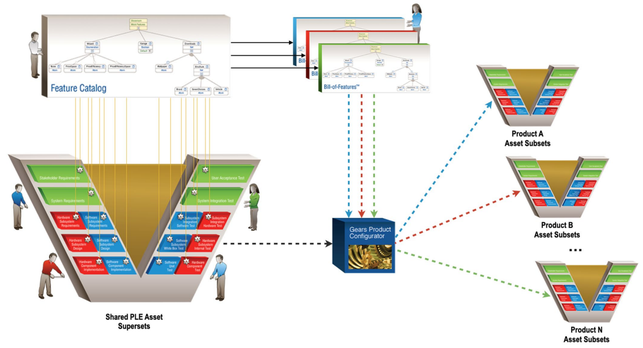
General Dynamics Mission Systems: Best Practices for Building a Feature Catalog



- Feature Catalog
  - Decision Tree of features
  - A feature catalog represents the full set of choices from which a Bill of Features for a product in a product line is constructed.
- Patterns for success
  - Top Down Modeling
    - It is our experience that often it best to think about a program or product like the customer does.
  - Feature Model Size
    - Software modularity and composability best practices will serve you well here.

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General Dynamics Mission Systems: Best Practices for Building a Feature Catalog

- Patterns for success
  - Five Whys
    - When eliciting features from subject matter experts, they may describe distinguishing characteristics using shared-asset-specific language.
  - Customer facing features and engineering implementation features
    - We want our customers involved in the process of discussing and evolving our production line.
- Antipatterns
  - Systems Model as Feature Model
    - There is no need to create features and wrap things in variation when no variation exists. This just adds effort and costs to your implementation with no value.
  - Swiss Army Knife
    - In our PLE implementations, you get credit for reusing something that someone else has shared. You get no credit for building something that someone might use in the future.

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