Managing Variation in Requirements and System Architecture with Pure Variants

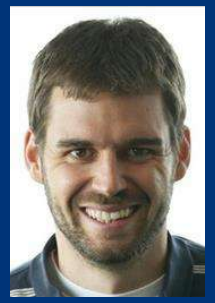
Lockheed Martin Space

Experiences and Lessons Learned

Nathan Shupe, Senior Staff Systems Engineer
Rebecca Cabrera, Systems Engineer

Introductions

Nathan Shupe



- Senior Staff Systems Engineer
- Product Line Engineering Team
- Lockheed Martin Space

Rebecca Cabrera

- Systems Engineer
- Product Line Engineering Team
- Lockheed Martin Space

Agenda

- Example Product Lines at Lockheed Martin Space
- Strategies
- Benefits
- Challenges and Successes

A dive into Lockheed Martin Space's experience with variation management

Example Product Lines at Lockheed Martin Space

- Satellite Bus Platform Product Line
  - A "first movers" product line
  - Leverages Pure Variants for requirement variation management and system architecture variation management

- Missile Payload Product Line
  - An internal research program
  - Leverages Pure Variants for variation management in both structural and behavioral system architecture

These examples were used to develop the general application of PLE methodologies at Lockheed Martin Space

Strategies

Feature Model Development Strategy

Defining Features

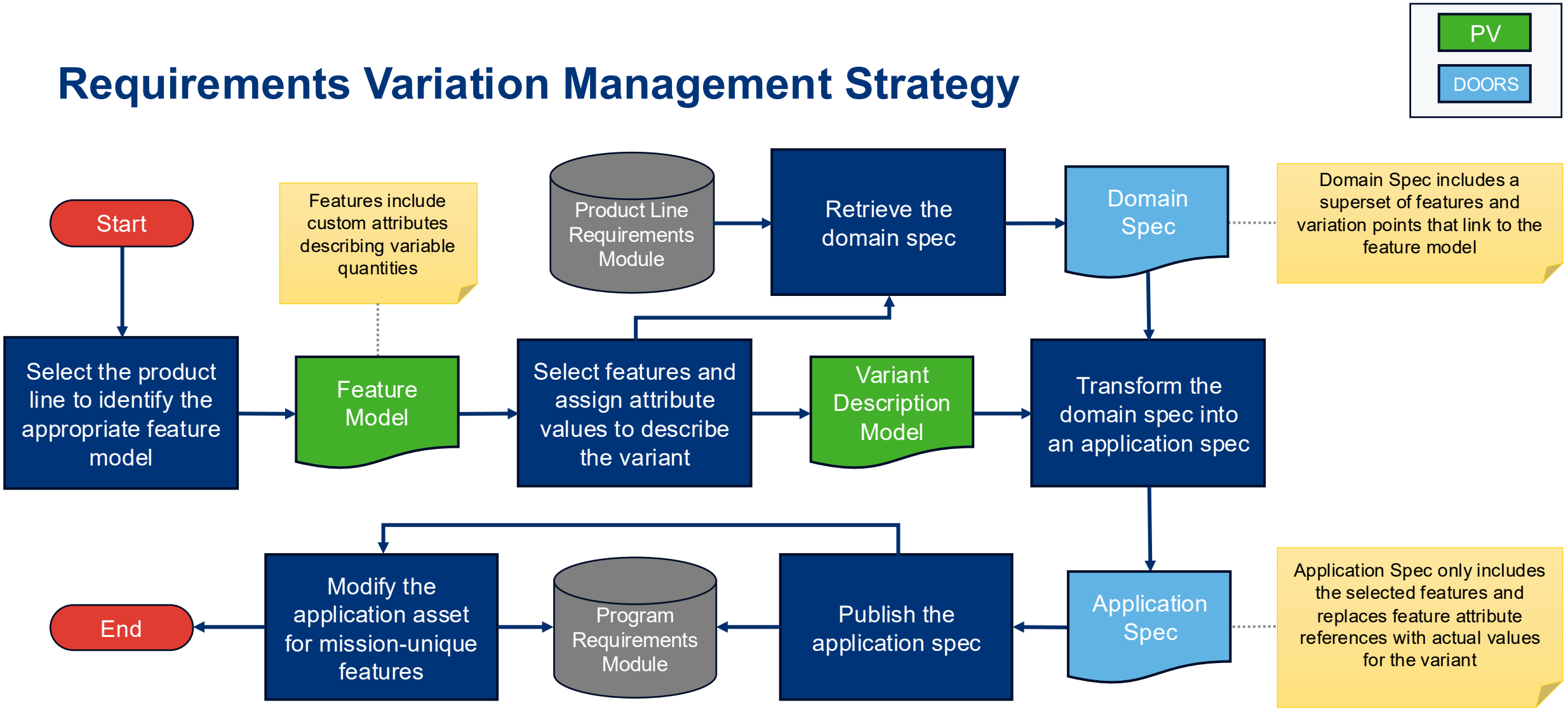
- Features focused only on the variability of the product line
- Features represented product missions and capabilities
  - Features were not created with program, hardware, or architecture focus
- Element attributes were used to define values associated with features

Restricting Feature Selection

- Element relations were applied to features to validate variant configurations

Features drive a mission-based product variant

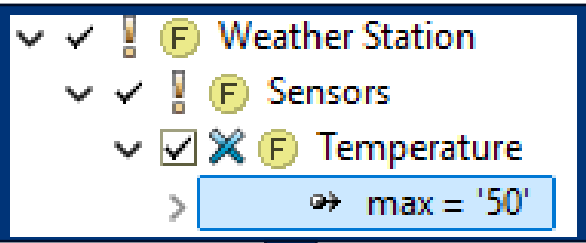
Requirements Variation Management Strategy



Process efficiently generates program-unique specifications for users of the satellite bus platform

Requirements Variation Management Strategy (Example)

Variant Description Model



Domain Spec

Custom ID	Object Text	pvRestriction	pvParameter
WXSTN-1	The weather station shall measure the ambient temperature up to a maximum of **[Temperature->max]** deg C.	Temperature	True

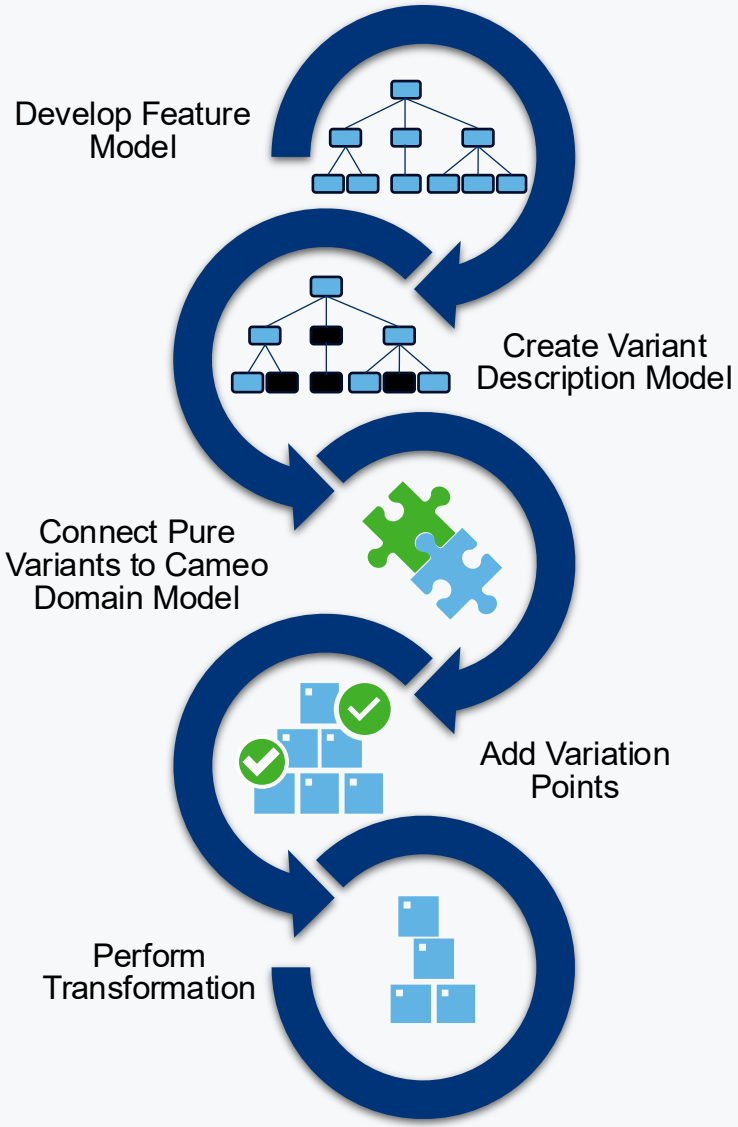
Application Spec

Custom ID	Object Text	pvRefID	pvParameter
WXSTN-1	The weather station shall measure the ambient temperature up to a maximum of **50** deg C.	1	True
LONDONSTN-99	The weather station shall measure relative humidity to an accuracy of 1% (1σ).		

System Architecture Variation Management Strategy

Applying Variation Points

- Structural Modeling
  - Variation points applied to identify variable components
  - Feature selection determined which variable components remained in the system
- Behavioral Modeling
  - Utilized decision nodes and applied variation points strategically such that the post transformation diagrams maintained an executable flow
  - Domain asset is easier to maintain with variation built into the behavioral diagram



PLE Born vs PLE Retrofit

PLE Born Missile Payload		PLE Retrofit Satellite Bus Platform
Began with the 150% solution in mind	⟷	Began with a made-to-fit solution and had to abstract back to the 150% level
Domain system model was created based off the 150% solution	⟷	A domain model of the 150% solution had to be compiled and created
Commonalities and variabilities were identified from the start	⟷	Commonalities and variabilities between existing specifications and models had to be retroactively identified
Business Development and Engineering had a common goal and remained connected throughout development	⟷	Business Development and Engineering had to retroactively align goals to conform to product line ideals

Pitching the product line first is easier than retrofitting a made-to-fit solution into a product line

Benefits

Variation Management in Numbers – Missile Payload

Understanding the Savings

These values represent estimates of hours saved for system tasks supporting Missile Payload System Requirements Review (SRR) when utilizing Lockheed Martin MFC's Missile Product Line (MPL).

Understanding the Numbers

Numbers were generated by a Lockheed Martin Space employee's SME knowledge, experience, and judgement after using the MPL on an internal research program.

Task	Percent Hours Saved Using MPL
Set Up Model	83%
Analyze Stakeholder Needs	63%
Trace Analysis Activities to Requirements	63%
Generate List of Resource Documents	60%
Identify ILS Architecture and Maintenance Approach	50%
Optimize and Evaluate Alternatives	33%
Analyze System Requirements	25%
Manage Requirement Traceability	25%
Identify Training Architecture	25%

~35% hours saved on tasks leading up to Missile Payload review using the MPL

Challenges and Successes

Challenges

Variation Management Across Networks

How do we manage domain assets on air-gapped networks?

Requirements to Architecture Syncing

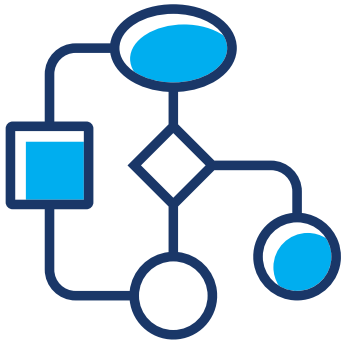
Adding another layer of complication to the synchronization process

Post-Transformation Cameo Clean Up

Removal of floating decision nodes in behavioral diagrams after transforming the domain model

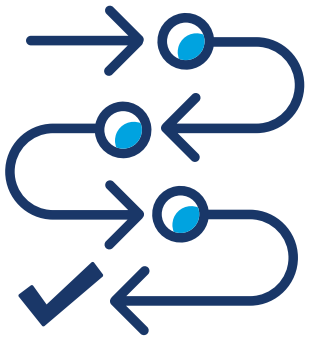
Successes

Utilized Pure Variants to **manage variation** in: requirements, structure and behavior system architecture



Defined and tested processes for **implementing variation management** across product lines (PLE born and PLE retrofitted)

Utilized PLE methodologies to **reduce level of effort** on recurring systems engineering tasks



Developed effective **governance methods** to manage changes across a product line

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