Product Line Requirements Engineering:
How Lockheed Martin Manages Product Lines in DOORS

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Common Product Line Initiative at LM MS2
Telelogic UGC 2008

- In pursuit of this core business objective
  - Finalizing a multi-year initiative to identify, evaluate and implement a leading-edge Common Product Line reuse strategy
  - Streamline systems and software engineering in each of its core product lines.

- Driving goal is to satisfy strong customer demand to reduce the time, cost and effort required to create, deploy and maintain products

- MS2 Program Management was looking for a joint BigLever and Telelogic Solution

“At Lockheed Martin, the timely and cost-effective delivery of the latest technological advances to our customers is mission critical. Our goal is to constantly ‘push the envelope’ in employing state-of-the-art product development tools and methods.”

– Norman Malnak, Chief Engineer & Vice President of Technical Operations
Lockheed Martin Maritime Systems & Sensors (LM MS2)
Why a Software-based Product Line Approach?

- **Economy of scale is key**
  - Today, product differentiation relies heavily on software
  - Greater profitability achieved when common product or manufacturing assets can be used for different “flavors” of a product
  - Satisfy strong customer demand to reduce the time, cost and effort required to create, deploy and maintain products

- **Virtually every reuse strategy was defined in the context of a product line**
  - Minimize duplicate effort in order to maximize commonality among design and implementation assets
  - Optimize reuse of effort across similar products within each of its product lines

- **In the world of hard goods, a product line refers to variations on a common theme**
  - Multiple products combined into one “line”, offering different features
  - Addressing diversity in customer needs for a particular kind of item
4 Keys to SPL Success at Lockheed Martin

- A shift in perspective
  - “The right point of view saves 20 points of IQ”

- The SPL Lifecycle Framework

- Incremental Transition to SPL Practice

- Executive & Customer Support for Transformation Change
The Challenge of a Program/Project Focus Approach

*Inherent Complexity Impedes Production, Reuse, and Growth*

**Vertical Product Team Perspective**

**N² Order Complexity with Linear Growth**
IBM BigLever Software-Based Product Line Approach

Shift in Perspective to an Efficient Means of Production

Feature-based Abstraction

Product Line Management

Feature and Variation Profiles

BigLever Gears
Product Configurator

Simplicity of a Single System

“Horizontal” Core Asset Perspective

Reusable Core Assets

Key

Variation Point

Projection

IBM Rational Tools

IBM Software Group | Rational software
The IBM BigLever Systems and Software PLE Solution
Making Tools, Process, and Best Practices Product Line Aware

IBM Rational
Tools

Gears SPL Framework

Example Reusable Core Assets
DOORS Requirements as Reusable SPL Core Assets

*Feature-based Requirements Engineering*
Requirements Engineering for Product Lines

The Requirements Process Shift in Perspective

- Current product-centric approaches lead to high complexity
  - Clone-and-own (and requirements branching)
    - For each new product, make a copy of requirements and modify
    - Leads to expensive duplication, divergence and merging
  - Attributes and scripting
    - Tag each requirement with one or more attributes about product diversity
    - Leads to high overhead
      - Major effort to define and implement attributes, dictionaries, semantics, schemas, scripts and filters
      - Labor intensive to revisit all requirements and attributes during maintenance and portfolio extension
  - One-size-fits-all
    - Write the portfolio variations and diversity directly into the requirements text
    - Leads to complexity and errors interpreting requirements for any particular product
Clone-and-own approach for Deriving a New Product

Product P

- P Stakeholder Requirements satisfies P Stakeholder Tests
- P System Requirements satisfies P Subsystem A Requirements
- P Subsystem A Requirements qualifies P Subsystem A Tests
- P System Requirements qualifies P Subsystem B Requirements
- P Subsystem B Requirements satisfies P Subsystem B Tests
- P Subsystem C Requirements satisfies P Subsystem C Tests

Product Q

- Q Stakeholder Requirements qualifies Q System Tests
- Q System Requirements qualifies Q Subsystem A Requirements
- Q Subsystem A Requirements satisfies Q Subsystem A Tests
- Q System Requirements satisfies Q Subsystem B Requirements
- Q Subsystem B Requirements satisfies Q Subsystem B Tests
- Q Subsystem C Requirements satisfies Q Subsystem C Tests

Product R

- R Stakeholder Requirements satisfies R System Tests
- R System Requirements satisfies R Subsystem A Requirements
- R Subsystem A Requirements qualifies R Subsystem A Tests
- R System Requirements satisfies R Subsystem B Requirements
- R Subsystem B Requirements satisfies R Subsystem B Tests
- R Subsystem C Requirements satisfies R Subsystem C Tests

Copied from

- R Subsystem C Requirements
- Q Subsystem A Requirements
- Q Subsystem C Requirements

satisfies

qualifies

Product Q

- Q System Requirements
- Q Subsystem A Requirements
- Q Subsystem B Requirements
- Q Subsystem C Requirements

satisfies

Product R

- R System Requirements
- R Subsystem A Requirements
- R Subsystem B Requirements
- R Subsystem C Requirements

satisfies

Product P

- P Stakeholder Requirements
- P System Requirements
- P Subsystem A Requirements
- P Subsystem B Requirements
- P Subsystem C Requirements

satisfies

qualifies
The Product Line Approach

Products Line Assets (superset)

- Stakeholder Requirements
- System Requirements
- Subsystem A Requirements
- Subsystem B Requirements
- Subsystem C Requirements

- Stakeholder Tests
- System Tests
- Subsystem A Tests
- Subsystem B Tests
- Subsystem C Tests

- satisfies
- qualifies

Business Strategy Requirements
Marketing Requirements
Product Management Requirements

Product Line

Feature Variability Model

- selected from

Product Specifications

- Product P
- Product Q
- Product R
- Product S

Variation Points

- contained in

New Product created with no further work on the assets

Satisfies
Qualifies
Embodies
Viewing Product Q

Specific Product Q

Product Line

Business Strategy Requirements
Marketing Requirements
Product Management Requirements

Product Specifications

Product P
Product Q
Product R
Product S
Feature Options

Feature Variability Model

Variation Points

Subsystem C
Subsystem B
Subsystem A
Stakeholder Requirements
System Requirements
Stakeholder Tests
System Tests
Subsystem A Tests
Subsystem B Tests
Subsystem C Tests

satisfies
qualifies

selected from

produces
drives

interprets

embodies
Viewing Product R

Product Line Assets (superset)

- Stakeholder Requirements
- System Requirements
- Subsystem A Requirements
- Subsystem B Requirements
- Subsystem C Requirements
- Stakeholder Tests
- System Tests
- Subsystem A Tests
- Subsystem B Tests
- Subsystem C Tests

Product Line

- Feature Variability Model
  - satisfies
  - qualifies

Product Specifications

- selected from

Business Strategy Requirements
- Marketing Requirements
- Product Management Requirements

embodies

interprets

produces

drives

satisfies

qualifies

Product P
Product Q
Product R
Product S
Feature Options
Systems Engineering and Software Based Product Lines

Symmetry in the ‘V’

Feature-based Abstraction

Profile A

Feature Profiles

Requirements

Design Models

Source Code

Unit Test Cases

Integration Tests

Subsystem Tests

Gears

Product Configurator

Reusable Core Assets

Key

☀ Variation Point

Projection

Product A

Integration Tests

Source Code

Unit Test Cases

Design Models

Subsystem Tests

Model A

...
Closing the Product Line Engineering Gap

**Feature-based Verification and Validation**

[Diagram showing a flow of information and processes related to product line engineering and verification and validation.]
Where are they today?

- “The right point of view saves 20 points of IQ”

- The SPL Lifecycle Framework

- Incremental Transition to SPL Practice
Thank You

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Learn more at:
- IBM Rational Software
- IBM Rational Software Delivery Platform
- IBM BigLever Systems and Software Product Line Solution
- BigLever Software Inc