



33rd Annual **INCOSE**
international symposium
hybrid event
Honolulu HI USA



Achieving agility and maximizing reuse of the Micro Vapor Cycle System Product Line with IBM Engineering Lifecycle Management

Developing Honeywell MicroVCS with IBM ELM

Speakers

Christine Shea, MASC



- Honeywell Aerospace
- Sr Systems Engineering Manager
- Environmental Control Systems

Christine has 14 years of experience in Aerospace control systems development and certification of integrated mechanical systems. Christine lead the deployment of an Agile Product Line Engineering strategy for Honeywell's MicroVCS offering.

Daniel Moul



- IBM
- Principal Product Manager
- Engineering Lifecycle Management

Daniel was a co-creator in the teams that invented OSLC Configuration Management ("Global Configurations") and brought requirements management to the IBM Jazz platform ("DOORS Next")

Agenda

- Honeywell Aerospace MicroVCS Product Line
- Reuse Pitfalls in Mechanical Systems
- Product Line Engineering and Scaled Agile
- Achieving agility and maximizing re-use with ELM and PV
- Business Outcomes

Honeywell | MICRO VCS

A Breakthrough Initiative (BTI), Honeywell's **Micro Vapor Cycle System (VCS)** is a reliable, integrated thermal management system providing efficient cooling performance at lower lifecycle cost. It is the ideal cooling solution for urban air mobility aircraft and military & civil helicopters where reduced size and weight are priorities. Cooling capacity is 20 KW and below, and the system is 100% electrically driven.

LIGHTWEIGHT

Micro VCS is engineered to be 35% lighter with optimal compressor technology

LOW MAINTENANCE

Oil-free technology allow this system to have no scheduled maintenance

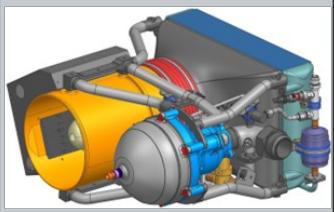
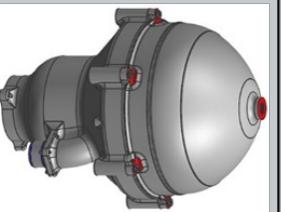
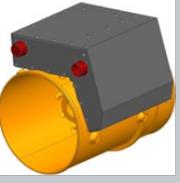
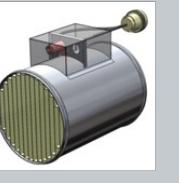
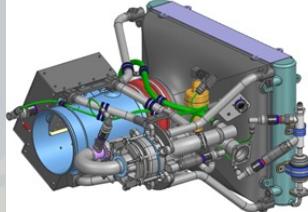
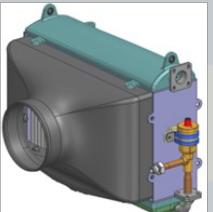
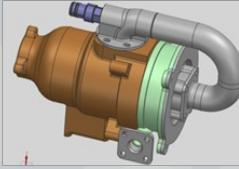
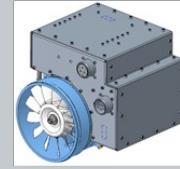
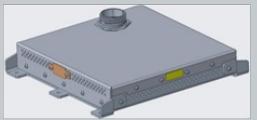
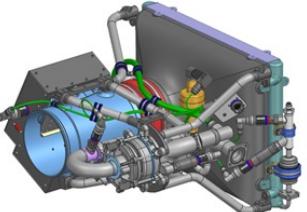
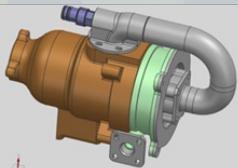
ENERGY EFFICIENT

Micro VCS is 20% more efficient than conventional vapor cycle systems

Environmentally Friendly

Honeywell's Solstice refrigerant has lower Global Warming Potential (GWP)

MicroVCS Product Line Overview

| Condenser Units | Evaporator Units | Compressors | Condenser Fans (& Motor Controller) | Evap Fans (& Motor/Heater Controller) | System Controllers | Controls & Software |
|---|---|--|---|---|--------------------|---|
|  20 kW | |  20 kW |  3300 CFM, 17 kW |  650 CFM, 4 kW EHC  4 kW Heater | | Digital Bus: CAN, ARINC-429 |
|  10 kW |  10 kW |  10 kW |  1500 CFM, 7 kW |  Single PBA | | Controls: Single-Evaporator, Dual-Evaporator |
|  6 kW |  6 kW |  6 kW | | | | |

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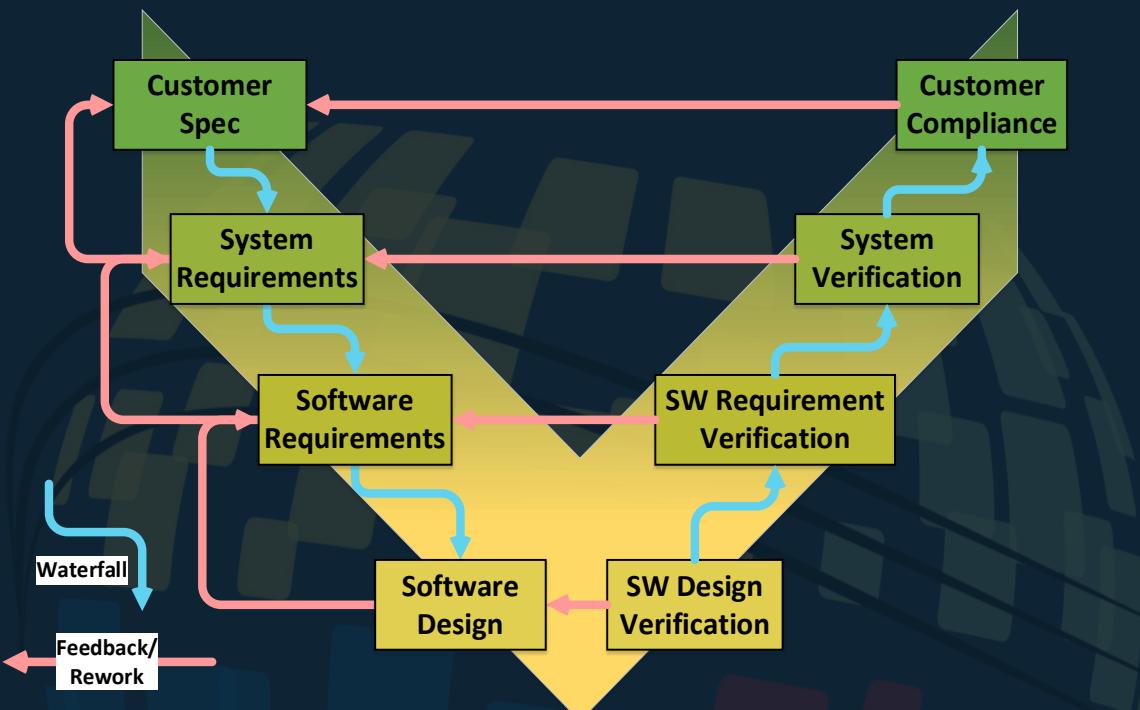
Reuse Pitfalls in Mechanical Systems

- Aerospace Mechanical Systems are *highly integrated* with the Aircraft envelope/interfaces – driving costly custom solutions
- *Dozens* of possible System variants
- Investments in Core products are often fruitless due to significant *customizations* driven by different customer applications
- Minor changes in components can have *large knock-on effect*
- The Core product is often in development alongside (multiple) customer-specific variants

Waterfall vs Agile and Associated Challenges

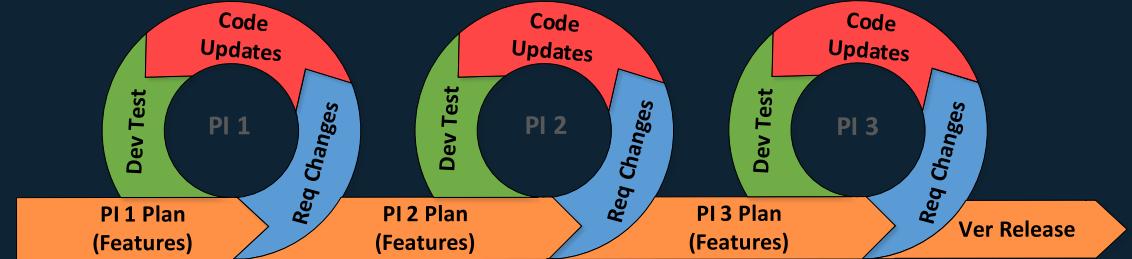
Waterfall

- Serial process with clear handoffs
- Full plan and budget visibility
- Not flexible, slow, late feedback



Agile

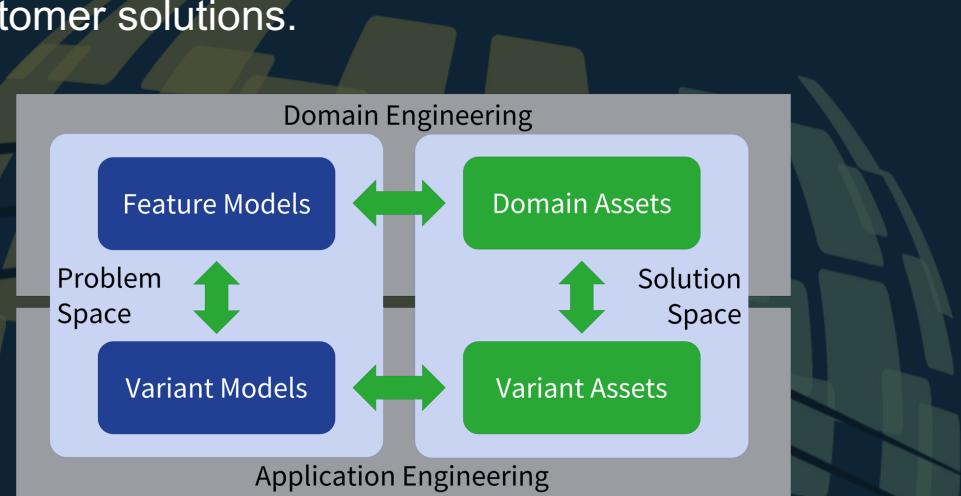
- Parallel process with incremental validation
- Flexible to change and customer feedback
- Reduced visibility to plan, scope and budget
- Hard to keep integrated teams aligned
- Challenging for HW



Solution: PLE and Scaled Agile

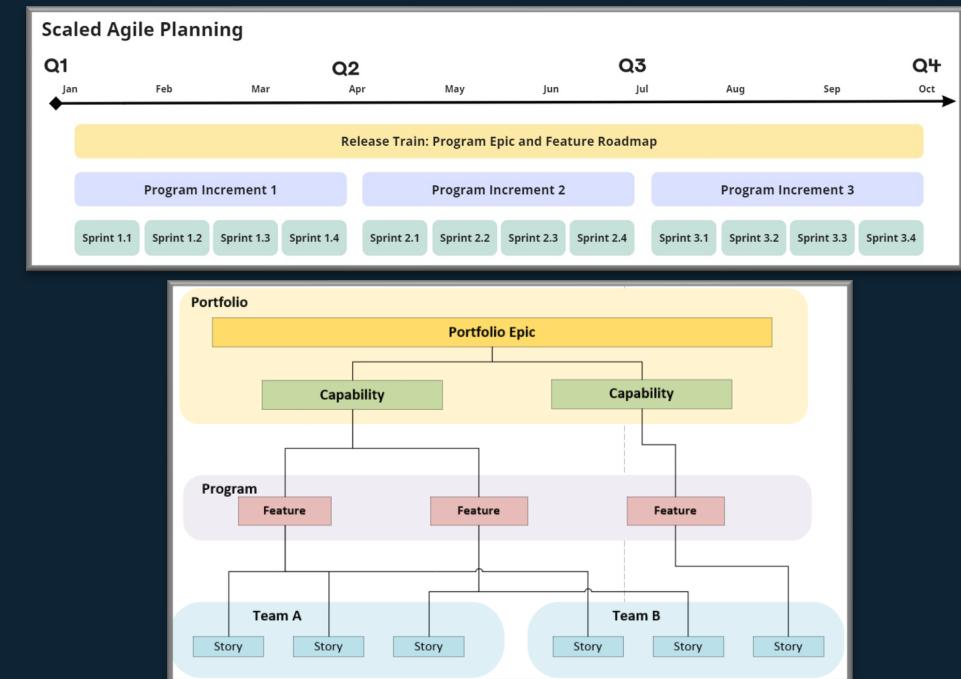
Product Line Engineering

- Establish a core library of shared assets, containing a superset of **Features** to produce **Variants**.
- Shared assets organized by component, with requirements and design artifacts mapped to key **Features**
- Enables rapid, **scalable** re-use to serve unique customer solutions.



Scaled Agile Framework (SAFe®)

- Scaled Agile enables **integrated** Scrum Team alignment
- Release Train containing Epics, Capabilities and Features to baseline and track **scope and budget**
- Detailed Stories per Team per Program Increment



IBM ELM and pure::variants Solution

Requirements Management (DOORS NG)

Collaborative, modular components and parallel streams
Integrated Change Sets
SSOT with requirement re-use

Model-Based Software Design (Rhapsody)

Full DO-178 traceability from Requirements to Design to Code.



Engineering Workflow Management (EWM)

Scaled Agile project management
Integrated Change Requests and Reviews
Software Configuration Control

Engineering Test Management (ETM)

Test Plans and Test Cases with full traceability to requirements. Integration with external test environments for test execution.

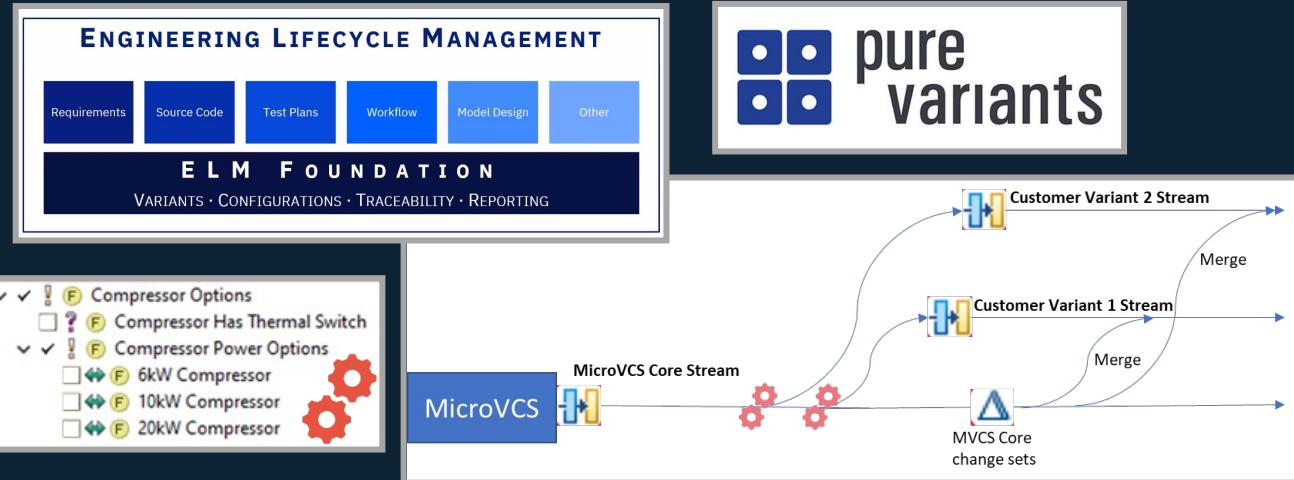
Product Line Engineering Variant Management

Global Variant Management: Full Digital Thread

PLE and SAFe® on MicroVCS with ELM and PV

Product Line Engineering Transformation

- ✓ Deployed next-gen tools (IBM ELM, pure::variants)
- ✓ Developed proven core building blocks and Feature models
- ✓ For a new variant of a system or component, automates:
 - ✓ Initial System, Equipment, Software and Hardware requirements
 - ✓ Initial Controller Software and Hardware Designs
- ✓ Enables parallel variant development



Scaled Agile Transformation

- ✓ Epics to track Core vs Customer scope
- ✓ Capabilities – Integrated, cross-team scope
- ✓ Features/Stories – Team-based scope
- ✓ Baseline Scope at the Capability and Feature level
- ✓ Change Management via new Capability and Feature approval
- ✓ Earned Value via Feature % Complete

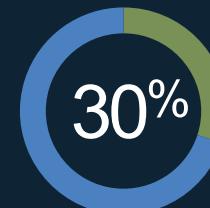
| Summary | ID | Work Item Type | Filed Against | Planned For |
|--|-------|----------------|----------------------------|----------------------|
| ↳ MicroVCS 6kW Core | 31239 | Program Epic | MicroVCS System ▾ | mVCS Release Train ▾ |
| ↳ System Requirements and Integration 6kW Core | 47145 | Capability | MicroVCS System | mVCS Release Train |
| ↳ System Pack Design and Analysis 6kW Core | 47146 | Capability | MicroVCS System | mVCS Release Train |
| ↳ Controls System Integration 6kW Core | 44281 | Capability | MicroVCS System | mVCS Release Train |
| ↳ Dynamic Model 6kW | 44277 | Capability | Control System Integration | mVCS Release Train |
| ↳ SIB Build 6kW | 44154 | Capability | SIB Test | mVCS Release Train |
| ↳ SIB Development Test Campaign 6kW Core | 44155 | Capability | MicroVCS System | mVCS Release Train |
| ↳ SIB Test Plan/Procedure Development CSI | 46203 | Feature | Control System Integration | PI 8 |
| ↳ SIB Test Execution and Analysis I | 46204 | Feature | Control System Integration | PI 9 |
| ↳ SIB Test Execution and Analysis II | 46205 | Feature | Control System Integration | PI 10 |

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MicroVCS Business Outcomes



Schedule Reduction on 1st Core Variant



Cost Reduction on 1st Core Variant.



Schedule Reduction on Customer Variant



Cost Reduction on Customer Variant



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