Maximize value through a modular platform by defining and controlling system interfaces.
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  - Johan Lukkien
Central Theme

• What is the best strategy to prevent unnecessary divergence of a product platform within a large global organization?

• How to define and manage a modular architecture and its interfaces in the R&D processes of complex R&D organizations. How to reduce technical diversity by means of methods, tools, processes, etc.?
Reference Architecture
• Static diagram
• Difficult to maintain
• Difficult to communicate
• Difficult to govern
• How are the requirements linked?
• Where are the interfaces defined?
• What/where is the impact if we change a component?
• …
Platforms
Scalable, Reliable & Cost Efficient Platforms
Systems, Subsystems, Modules, Components, Interfaces

Re-use core modules
- Greater economies of scale
- Greater economies of learning
- Greater buying power
- Reduced component inventories
- Simplified product support requirements
- Longer life cycle, design refinements that improve reliability, performance and cost
- Reduced development time, resources and cost for new product variations and generations

Standardized module interfaces
- Interchangeability of non-core modules
- Improved ability to source modules/components
- Introduce more product variations
- Utilize development capabilities of module/component suppliers
- Allows for late customization
- Greater speed in upgrading performance by introducing improved modules

(1) Stable modules (‘core’)  
(2) Varying platform modules (‘complements’)  
(3) Interfaces, design rules that allow core and complements to operate as one product

Platforms combine stability and variety in architecture
Organization Perspective
Organizational Architecture
How to manage a platform evolution...globally?

• Context
  – Global development organization
  – One reference architecture
  – Organically grown product platform
  – Multiple cultures
  – Multiple organization structures
  – CoEs for System development
  – CoEs for Component development
  – Concurrent sourcing

• Challenges
  – Culture (flat, hierarchical, opportunistic, risk averse, etc.)
  – Environmental differences, geopolitics
  – Product/market complexity
  – Legacy vs. no-legacy
  – Innovation freedom & speed
  – Platform divergence
  – Configuration management
  – Life cycle management
Requirements Analysis
Needs, Drivers, CTQs

<table>
<thead>
<tr>
<th>Need ID</th>
<th>The Need</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN01</td>
<td>Manage the evolution of a product platform in a controlled manner</td>
<td>1</td>
</tr>
<tr>
<td>CN02</td>
<td>Governance processes and tooling to make, communicate, store and ratify product configurations</td>
<td>2</td>
</tr>
<tr>
<td>CN03</td>
<td>Maintain product innovation freedom</td>
<td>3</td>
</tr>
<tr>
<td>CN04</td>
<td>Maximize modularity and component re-use</td>
<td>4</td>
</tr>
<tr>
<td>CN05</td>
<td>Minimize End-to-End product development costs</td>
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</table>
CTQ ID | CTQ | Rank
--- | --- | ---
UCTQ005 | A standardized way of representing the physical architecture of MR products | 1
UCTQ001 | A stable reference architecture that represents platforms, systems, subsystems, modules and interfaces | 2
UCTQ002 | A tool that can capture and store multiple versions of a physical architecture | 2
UCTQ003 | A networked tool that has access control and version control | 2
UCTQ006 | A governance model around the tool usage that enforces design authority across a global organization | 2
UCTQ007 | Convenience and simplicity of function and interface representations | 6
UCTQ004 | A networked tool that tracks changes and facilitates review and sign-off | 7
UCTQ008 | Tool output that is visual in nature and easy for non-experts to understand | 8
UCTQ009 | Automated generation of Interface Control Documents (ICDs) | 9
UCTQ010 | Tool input that is logical, intuitive and efficient | 10
UCTQ012 | Separation of function and interface attributes | 11
UCTQ011 | A tool that can accommodate templates | 12
Interface Management
The interfaces imply the architecture
The goal of interface management is to identify, define, control and verify interfaces. This will ensure:

- Modular Platform Architecture is maintained.
- Left shifting the treatment of interfaces in System Architecture rather than leaving it until after the physical design needs integration.
- Improved stakeholder communication with defined interface requirements and constraints.
- Increasing efficiency and productivity of Systems Engineering and Product Development.

The Strategy – Manage The Interfaces

The Key To Modular Platform Architecture

- Establishing a governance process to manage and control interface evolution with the aim of preventing unnecessary and costly divergence.
- Building Digital Twins, on interface level, of product system architectures and configurations.
- Digital Twins will be used to rationalize and standardize on interfaces.
- Making an inventory of all interfaces in the system.
- Creating a standardized representation of interfaces using MBSE tooling.
- Creating Interface Libraries.
- ICD generation from tool.
Strategy – Manage The Interfaces
The Key To Modular Platform Architecture

MRI Systems
- Well established, evolves slowly
- Well established, evolves slowly
  
  (Logical interfaces)
  
  Well established, evolves very slowly

Established, evolves quickly
  
  (technology innovation, supplier chain evolution, cost)
  
  (Physical interfaces)

https://www.eclipse.org/capella/arcadia.html
Choosing A Tool

CAMEO Systems Modeler

No Magic's Cameo Systems Modeler is a Model-Based Systems Engineering (MBSE) solution in one easy-to-use package, enabling single users or an entire engineering team to create, collaborate, and manage systems requirements and designs.

Cameo Systems Modeler is based on the award-winning MagicDraw modeling platform. The solution retains all the best diagramming, teamwork, persistence and documentation capabilities, while offering more customized capabilities tailored to systems engineering needs.

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In Progress

https://www.3ds.com/products-services/catia/products/no-magic/cameo-systems-modeler/
Examples
Cabinets Example
Making an inventory of interfaces

Cabinets contain interfaces to every subsystem
Cabinets Example
Making an inventory of interfaces

Multiple configurations of cabinets
Create compositions by selecting the right variants

Different views for compositions
1. Show only components
2. Show components with properties (as shown in diagram)
3. Show components with properties and ports (shown in next slide)
# White Box ICD Table
With cable and connector details

<table>
<thead>
<tr>
<th>#</th>
<th>Part A</th>
<th>Port A</th>
<th>Part A Features and Values</th>
<th>Part B</th>
<th>Port B Features and Values</th>
<th>Constraints</th>
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<tbody>
<tr>
<td>1</td>
<td>ABO</td>
<td>ABO</td>
<td>Cable = CABLE 50.0.2MM SHUL/CSA</td>
<td>T Sensor Unit</td>
<td>T Sensor Unit</td>
<td>RS-X1</td>
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<td>2</td>
<td>ABO</td>
<td>ABO</td>
<td>Cable = DUAL STEP IND POF</td>
<td>Basic Cabinet DACC-C2 ASSY</td>
<td>Basic Cabinet DACC-C2 ASSY</td>
<td>RS-X1</td>
</tr>
<tr>
<td>3</td>
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<td>ABO</td>
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<td>ABO</td>
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<td>RS-X1</td>
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<tr>
<td>7</td>
<td>ABO</td>
<td>ABO</td>
<td>Cable = WIRE INS AWG25 5.5MM S/FTP OQ</td>
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<td>Basic Cabinet DACC-C2 ASSY</td>
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<td>8</td>
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<td>Ethernet Switch</td>
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<td>Basic Cabinet DACC NO-CC ASSY</td>
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<tr>
<td>12</td>
<td>Ethernet Switch</td>
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<td>Cable = LCT Duplex fiber FO 50/125 UM</td>
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<td>MA-UPS</td>
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<td>Basic Cabinet DACC-C2 ASSY</td>
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<td>Cable = USB A</td>
<td>Basic Cabinet DACC-C2 ASSY</td>
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</table>
Sub-System Modelling
Example: Cooling Unit (High Level View)
Sub-System Modelling
Example : Cooling Unit (Detailed View)
Interface Control Documents (ICDs)
Feedback from MR Colleagues

Feedback from Colleagues

a. Senior Systems Engineer
Views and Tables look good, feedback mainly on technical content like to add position of components in cabinet

b. Senior Systems Architect
Appreciates the use of tool for interface management
New Use case -> Power Budgeting Models

c. System Integration Lead
Views and Tables look good
New use case-> Capture interfaces with automation test tools

d. Systems Engineer
New Use Case -> Link Interface requirements from ALM to Interface Models

e. Reliability Engineer
This will help in doing FMEA’s.
New Use case -> Can we use cameo for FMEA’s also?
Conclusions

• Strict central control over every point of innovation is unrealistic in a global organization

• Decoupled development organizations need freedom to innovate, but without breaking the platform

• Effective management of a product platform is facilitated by:
  – A core team of Systems Architects
  – An established and accepted reference architecture
  – Clear definitions of architectural entities (modules, interfaces,...)
  – A governance model that is operable across a global organization

• The system interfaces represent the essence of both the architecture and the product function both collectively and of individual modules

• There are suitable tools to facilitate the governance of interfaces

• Governance of system interfaces minimizes platform divergence and enables to decouple innovation and technology evolution within modules

• We are at the start of the journey