SysML 2.0 Interface Concepts Modeling Core Team Status Update

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Introduction

Objectives

- Improve Interface Modeling efficiency with more mature constructs and automation
- Improve Interface Modeling consistency across domains with standard based rules
- Clarify, define tool implementation concepts for modeling Interfaces

Approach

- Review Interface Needs Document
- Demonstrate current limitations with notes and issues
- Add Interface concepts to SECM concept model
- Derive requirements to address notes and issues
- Leverage other services where possible to meet requirements
- Define user-level languages to accomplish goals (transformation, simplification, query)
- Illustrate concepts with example from HSUV Change Scenario
- Ensure all kinds of interfaces are addressed: Electrical, Hydraulic, Pneumatic, Mechanical, Software, Human, etc.

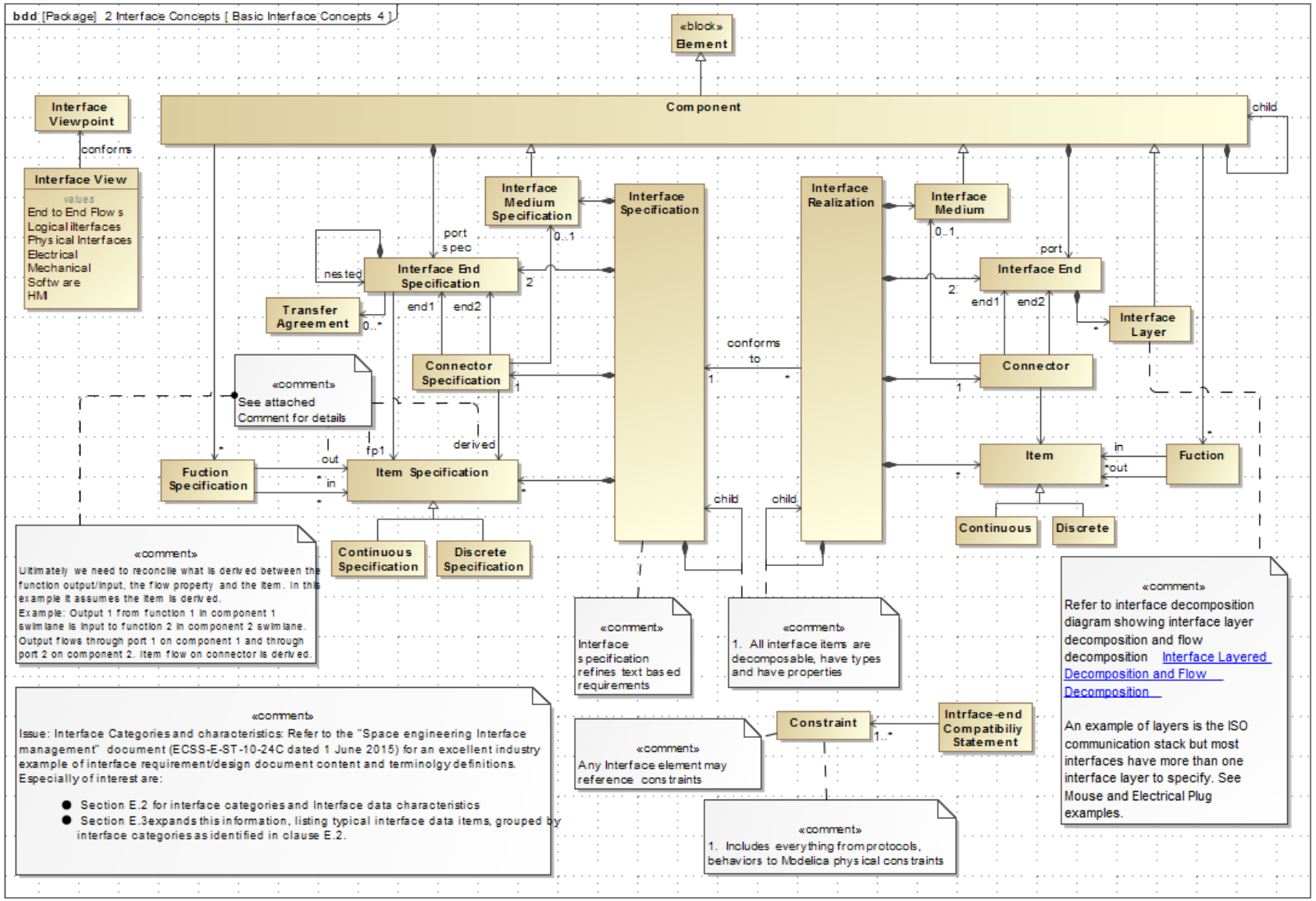
Interface Concept Model

Needs Document Quick Review

- Did presentation on Interface Needs document at Orlando meeting in June

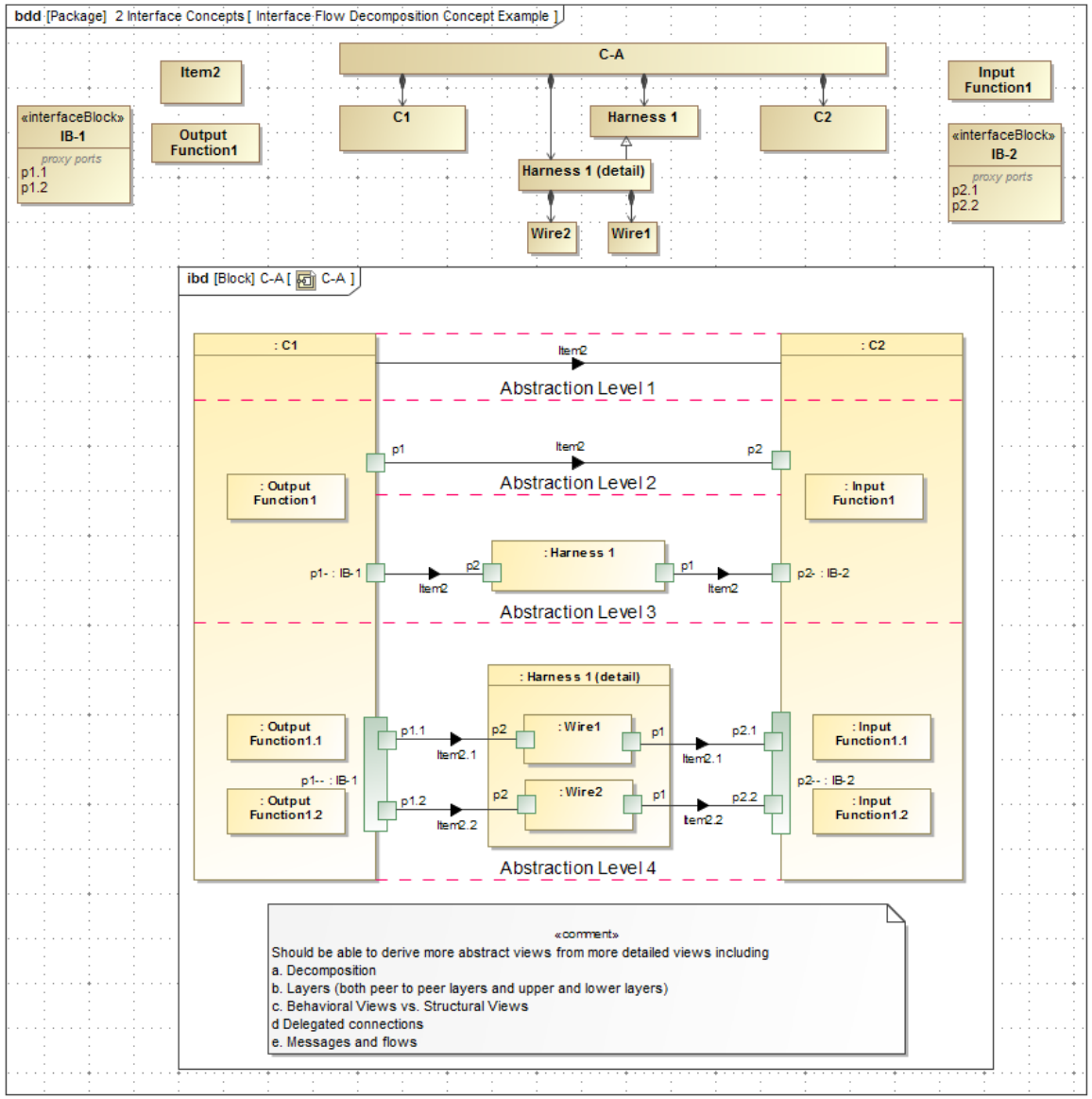
- Interface Concept Model
- Interface Specification vs. Realization
- Item Flows
- Transfer Agreements
- Interface Abstraction Levels
- Interface Layers
- Physical geometry
- Interface Tables
- Libraries

Interface Concept Model



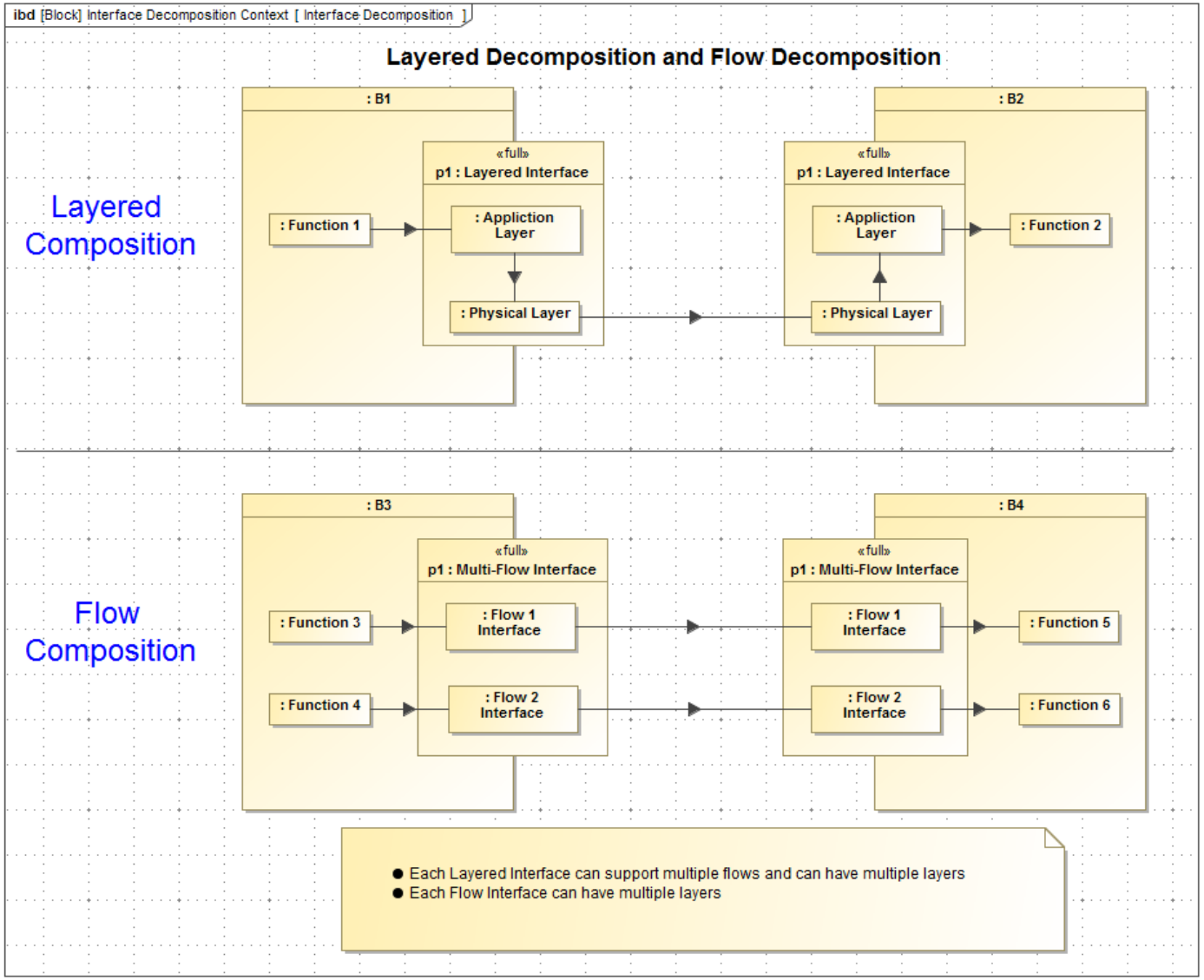
From John Watson's Interface Needs Presentation

Levels of Abstraction



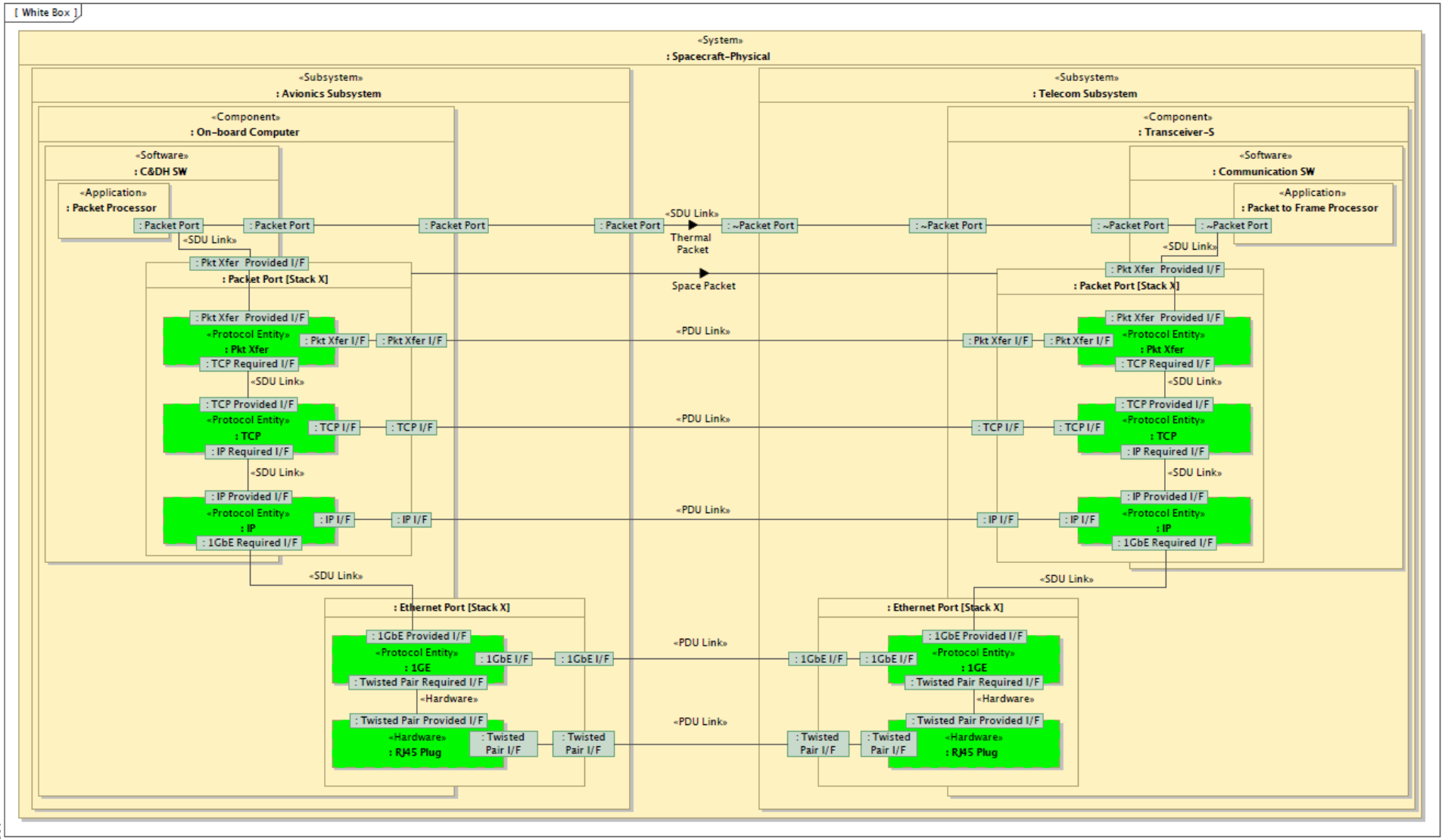
From John Watson's Interface Needs Presentation

Interface Composition



From John Watson's Interface Needs Presentation

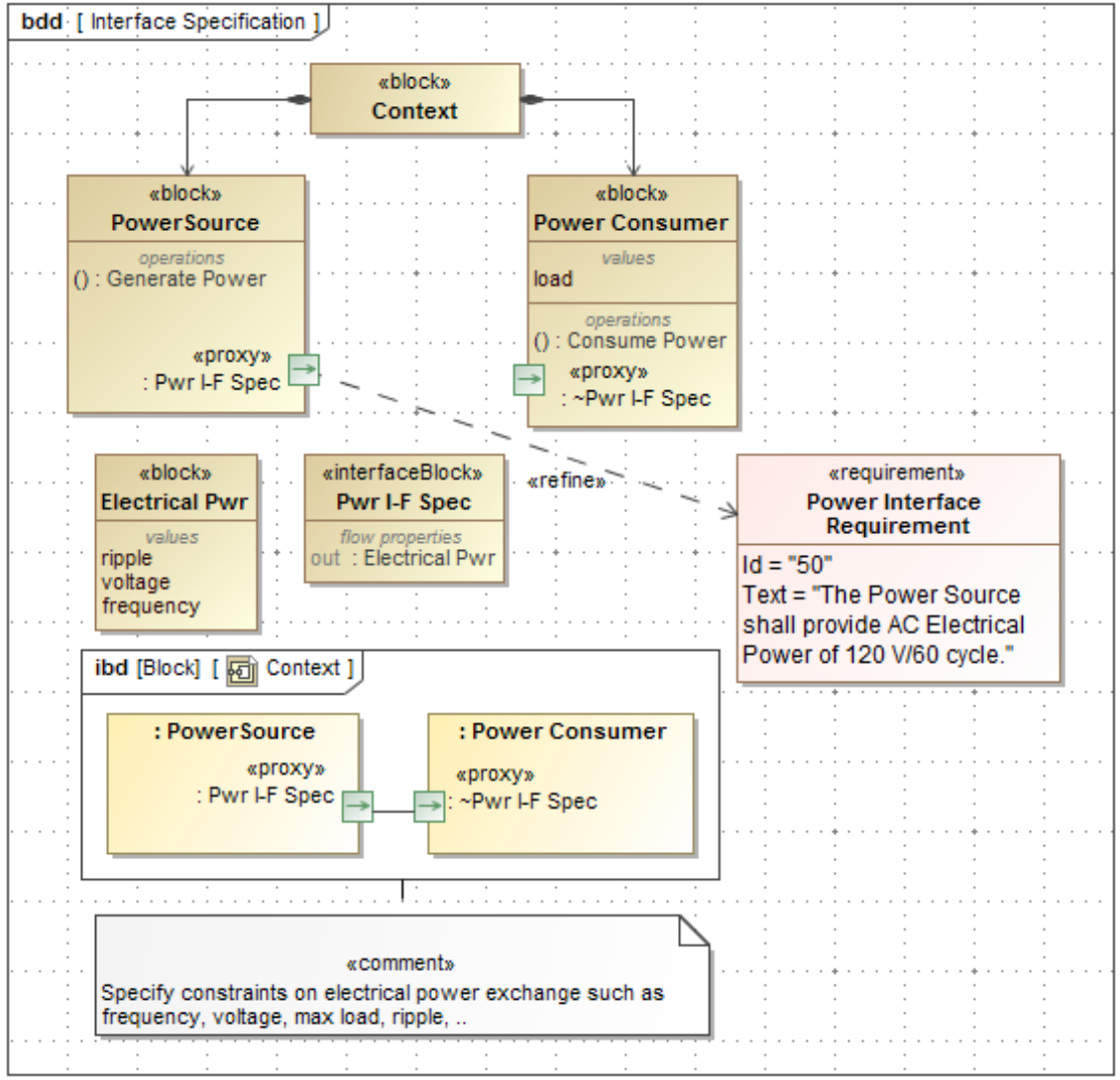
Layered Interface

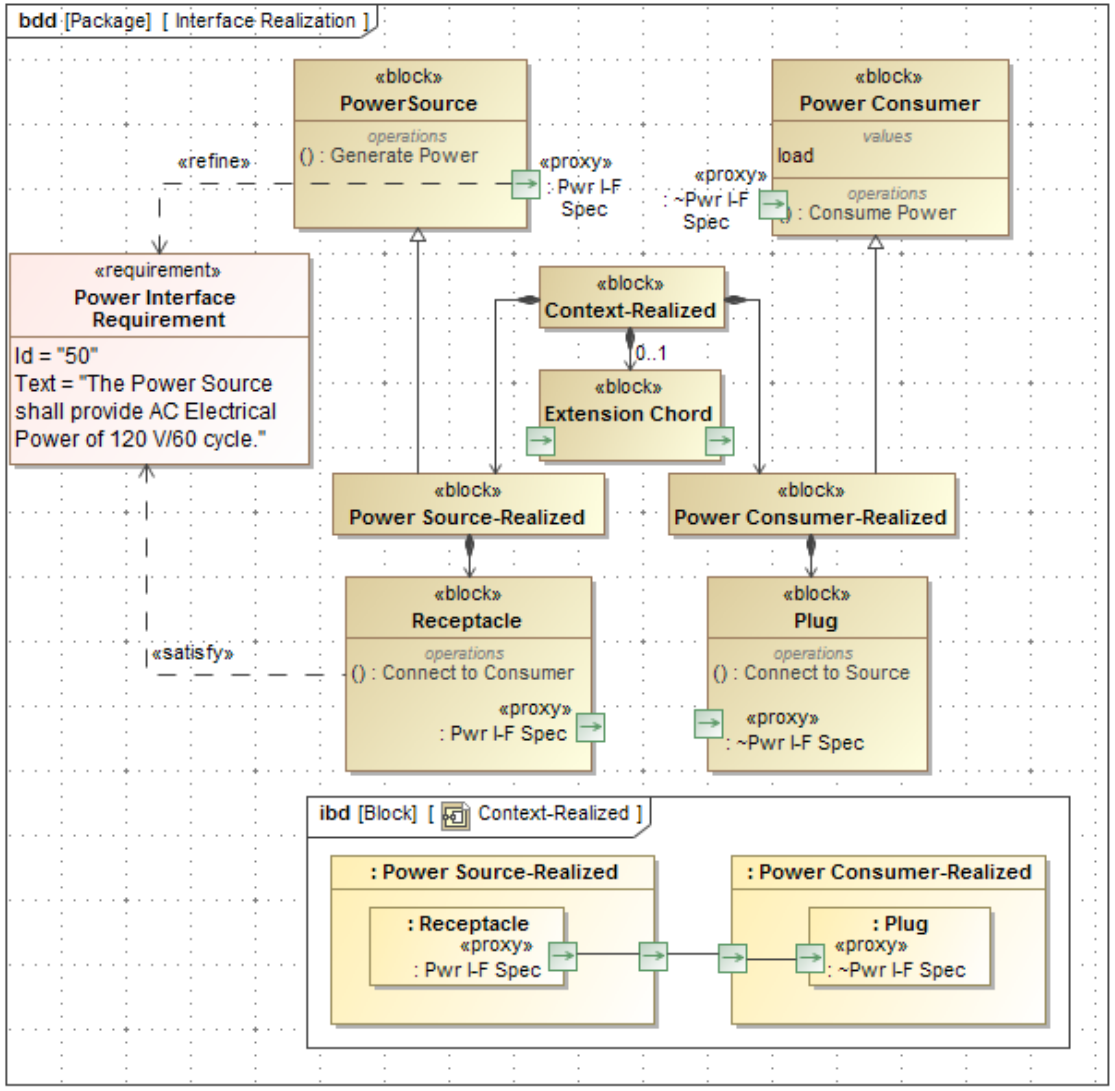


From John Watson's Interface Needs Presentation

Specification and Realization

From John Watson's Interface Needs Presentation





HSUV Use Case

Tire Pressure Control System

HSUV Change Proposal Scenario A Example

Trade Study for Tire Pressure Control System

1. **Interface Concepts** - Requirements for Interface concepts in the concept model
2. **Model Elaboration** - Model elaboration and inference via transformation language, user extensible
3. **Visual Simplification** - for SysML working diagrams
4. **Visualization Sharing** - to incorporate visualizations from other tools, and provide to other tools (e.g. 3D CAD)
5. **Cross-Model Navigation** - from model elements in SysML to model elements in other tools via persistent cross-linking
6. **Properties** - to describe interfaces
7. **Library** - re-usable elements for interfaces

Interface Concepts

- Provides ability to define the specification (the “What”) of a Tire Pressure Control System without over constraining the design alternatives (the “How”) for the trade study
  - Add air compressor to the car and identify high level interfaces
  - Mechanical interface to existing component X (frame)
  - Electrical interface to existing component Y (power subsystem)
  - Data interface to existing component Z (car’s computer)
  - Thermal interface to existing components (nearby components with which it exchanges heat)
  - etc.

Model Elaboration

- Helps ensure that the Tire Pressure Control System interfaces specification leverages existing standards currently utilized within the HSUV, or alternatively, industry standards
  - Mechanical Interface is specified as 4 bolt pattern, shock mounted attenuation
  - Electrical Interface is elaborated to specify a 12V DC Power and Return
  - Data Interface is specified as Controller Area Network (CAN) subscribing to messages for Vehicle Speed, Transfer Case Mode (2x4/ 4x4), Terrain Selector (Optional)

Visual Simplification

- Allows the Tire Pressure Control System to be assessed during the trade study at the right level of detail/ abstraction for evaluation and scoring
  - Mechanical Interface may be simplified to a single connector with only the shock mount thickness presented for each alternative
  - Electrical Interface may be simplified to show a single connector with Power (Watts) presented for each alternative
  - Data Interface may be simplified to show a single connector with only optional Messages supported for each alternative presented

Visualization Sharing

- Allows the components of the Tire Pressure Control System to be visualized within the 3D solid modeling environment for packaging, assembly instructions assessment of trade study
  - Compressor space claim alternatives
    - Under hood
    - Under 2nd Row Seats
    - Behind Rear Wheel Well
  - Each mounting location impacts
    - Assembly plant installation
    - Cabling length, Pneumatic Hosing Lengths, etc.

Cross-Model Navigation

- Allows Tire Pressure Control System interface properties (Bolt sizes, torque, etc.) to be integrated with other analyses (e.g. Human Factors, assembly operations/ instructions, etc.)
  - Mounting Bolt sizes and torque must be evaluated against current assembly plant tooling and Human Factors analyses
  - Electrical, Data, Pneumatic connection locations on compressors are also evaluated for sequencing within assembly line

Properties

- Allows design constraints to be defined for the Tire Pressure Control System interfaces (e.g. Vehicle Speed data refresh rate, Mounting bolt torque, etc.)
- Makes for a more comprehensive trade study assessment of alternatives
  - Electrical Power for each alternative that utilizes existing spare Fuse Box slots are less risky
  - Data refresh rates for each alternative that are already supported by the vehicle network are less risk
  - Mounting Bolt Torque values that are same as current assembly plant tooling are less risky

Library

- Provides library of interface standards (e.g. signal and pneumatic interfaces) that can be leveraged for Tire Pressure Control System.
- Use of existing standards would minimize the risk of an alternative in trade study
- Use of open standards reduces the risk to integrate future upgrades

Requirements

Requirements

- Start with requirements for new interface concepts from the concept model
- Rely heavily on other services of SysML 2.0
- Minimize redundancy stored in model through use of rule-based techniques
- Many of the limitations of SysML identified in the Interface Needs document are broadly applicable beyond Interfaces
- Categorized requirements based on which service we might rely on
  - Need to work these with leads of other SysML 2.0 WGs
- Extensible library of re-usable components
- Working Groups identified to date
  - Model Construction, Visualization, Model Management, Properties

Categories of Requirement

1. **Interface Concepts** - Requirements for Interface concepts in the concept model
2. **Model Elaboration** - Model elaboration and inference via transformation language, user extensible
3. **Visual Simplification** - for SysML working diagrams
4. **Visualization Sharing** - to incorporate visualizations from other tools, and provide to other tools (e.g. 3D CAD)
5. **Cross-Model Navigation** - from model elements in SysML to model elements in other tools via persistent cross-linking
6. **Properties** - to describe interfaces
7. **Library** - re-usable elements for interfaces

Interface Concepts

- This class of requirement defines the concepts specific to interfaces
- These three specify the relationship between Interface Specifications, Interface Realizations and textual Requirements

Requirement	Needs Document
The Interface Specification elements shall refine textual requirements.	5.1.1
The Interface Realization elements shall satisfy textual requirements.	5.1.1
The Interface Realization elements shall conform to Interface Specification elements.	5.1.1

Model Elaboration

- Model elaboration is meant to remove the tedium of constructing models with many detailed elements – automation
- Start with a simple model and then selectively elaborate it
- Each elaboration can replace or modify the previous elements
- Reduces redundancy

Requirement	Needs Document
SysML shall specify a language to describe model transformations.	5.5.x
SysML shall allow the user to extend existing transformations, and create new ones, using the transformation language.	5.5.x

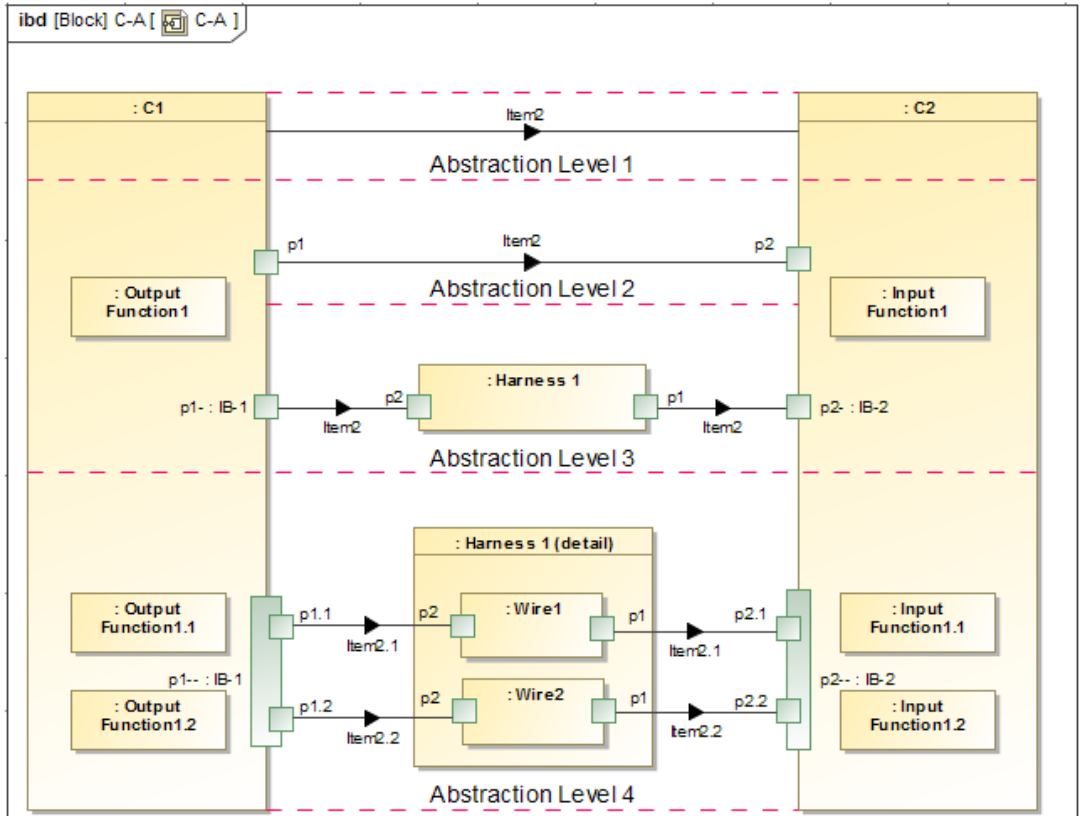
Visual Simplification

- Visually simplify working SysML diagrams, as distinct from viewpoints and views
- Takes a complex, elaborated model and makes it diagrammatically simple

Requirement	Needs Document
The Interface Specification Element shall be shown in views at different levels of selectable decomposition.	5.8.1 5.8.5
The Inferface Realization Element shall be shown in views at different levels of selectable decomposition.	5.8.1
The interface elements shall be shown with a selectable less or more detail of abstraction.	

Elaboration and Simplification, Two Sides of the Same Coin

User driven elaboration from less detail to more



Automated visual simplification from more detail to less

Eliminates redundancy of storing all for versions in the model simultaneously.

Visualization Sharing

- Allow SEs to reveal physical views of a system as they do SysML views
- We did not want to make SysML tools into 3D CAD tools
- So, we rely on an interface to existing external 3D CAD tools

Requirement	Needs Document
SysML shall provide a local display capability in which to show visualizations and views of data from external tools and resources.	5.6.1
SysML shall provide visualizations and views for display in other external tools and resources.	5.6.1

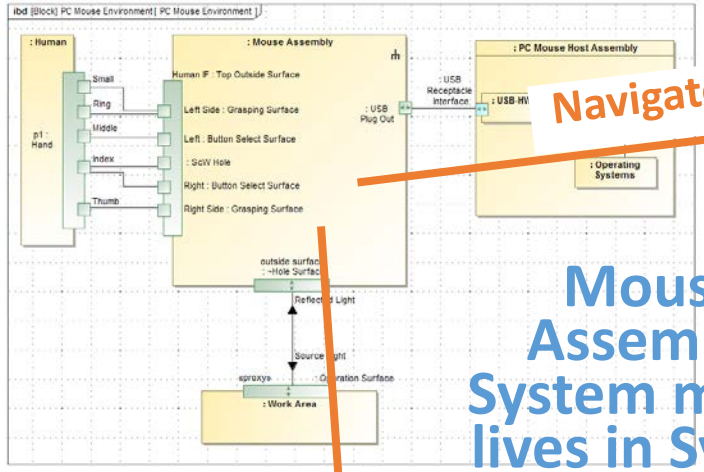
Cross-Model Navigation

- Enables simultaneous use of multiple tools in a diverse environment
- User navigates to external tool and to corresponding element
- Pairs with requirement for SysML query language
- User pulls up 3D CAD visualization of corresponding element

Requirement	Needs Document
SysML shall link SysML model elements to model elements of external tools and resources using a persistent, unique and navigable external identifier.	5.6.1
SysML shall navigate to model element in external tools and resources using the external identifier.	5.6.1

Cross Model Navigation and Visualization Sharing in Action Together

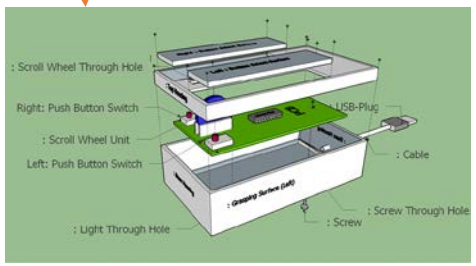
SysML Tool



Navigate to External Tool

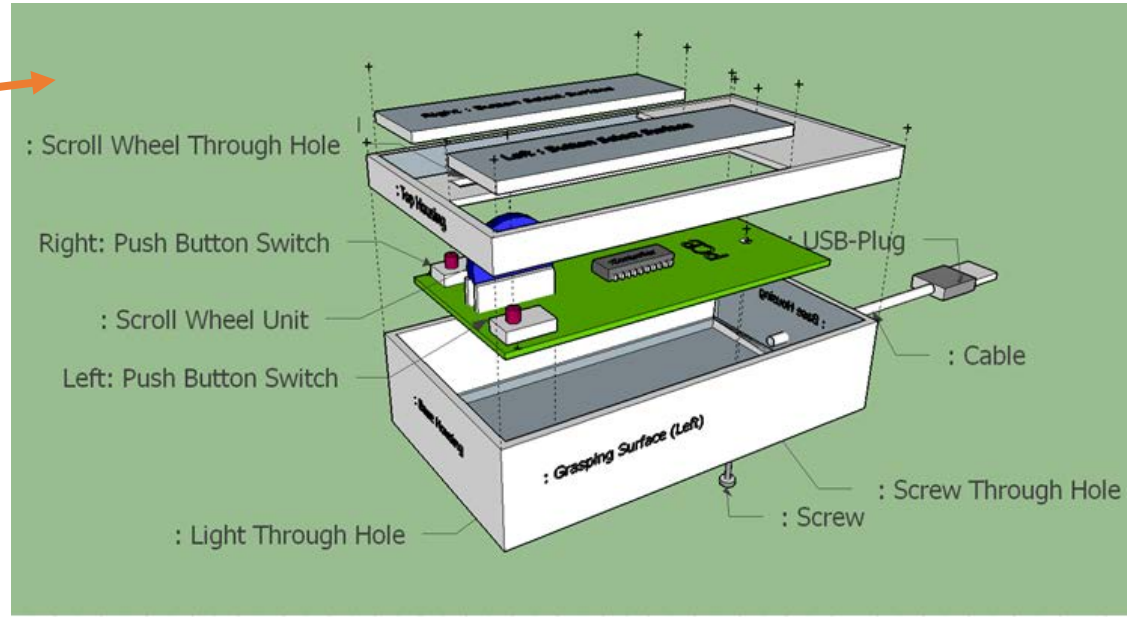
Mouse Assembly System model lives in SysML tool

Show Shared Visualization in SysML Tool



Shared Visualization

3D CAD Tool



Local GUI Interface

Mouse Assembly 3D model lives in this tool

Properties

- Interface concepts are characterizable like any other SysML element
- The characterizations need to follow the rules of inheritance and structural composition

Requirement	Needs Document
The Connector Specification element shall allow constraints that characterize the element to be added.	5.2.4a
The Connector Realization element shall allow constraints that characterize the element to be added.	5.2.4a
Interface concept elements shall be characterizable by properties separately for different uses in the same context.	5.2.4a

Library

- We're proposing that SysML define re-usable libraries
  - Interface concept elements for common kinds of interfaces (standards)
  - Model elaboration rules
  - Visual simplification rules
- Languages for rule specification shall be defined as part of SysML

Requirement	Needs Document
SysML shall provide a library of model elements for commonly used interfaces.	5.7.1
SysML shall provide a library of model transformations, specified in its model transformation language, to assist the user to elaborate parts of an interface.	5.5.x
SysML shall provide a library of visual simplifications, specified in its model transformation language, to assist the user to simplify SysML diagrams.	5.8.1

Demo