MBSE DESIGN PATTERN FOR NON-STANDARD INTERFACES

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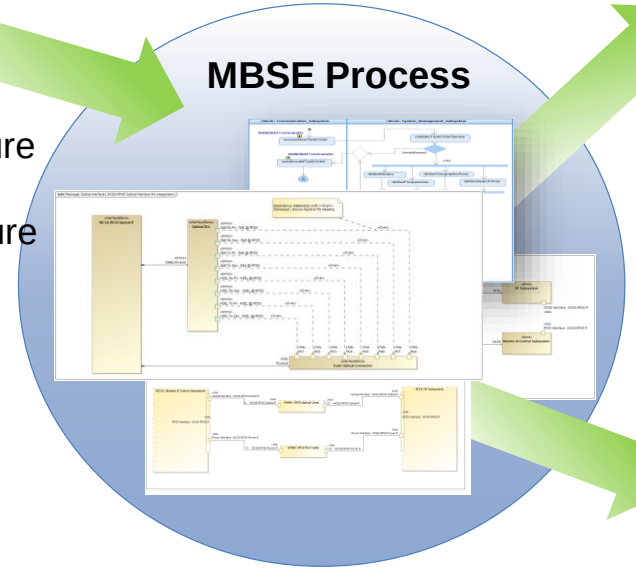
Overview of System Modeling

- Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases [1].

System Engineering Concerns

- Sponsor CONOPS
- Stakeholder Needs
- External Interfaces
- System Requirements
- Proposed Signal Architecture
- Proposed C2 Architecture
- Proposed Power Architecture



Software Architecture

- System CONOPS (Behavior)
- Internal Interface Definition
- Software Requirements Definition

MBSE Facilitates

- Iterative Integration
- Segment Configuration
- Managing System Interfaces

SI&T

- Test Case Definition
- Requirements/Test association
- Connection Diagrams (Structure)

- ➢ MBSE does not replace traditional document-based SE, MBSE formalizes it
- ➢ MBSE combines traditional methods and best practices with rigorous modeling techniques [2]

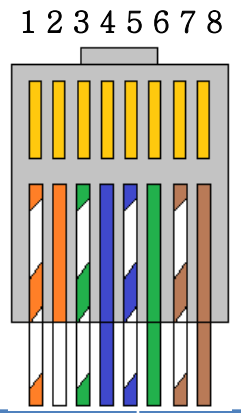
Importance of Interface Design to Systems Engineering

- Defining system interfaces is at the center of systems engineering
- The system engineer is responsible to define the overall characteristics of the interfaces

- Keys to successful interface design:
  - Specify relevant properties and behavior of each part of the system
  - Identify the connections between each system component
  - Identify connection types
    - Classification (Hardware, Software, etc.)
    - Constraints (Reliability, Physical, Environmental, etc.)
    - Protocol (TCP, HTTP, etc.)

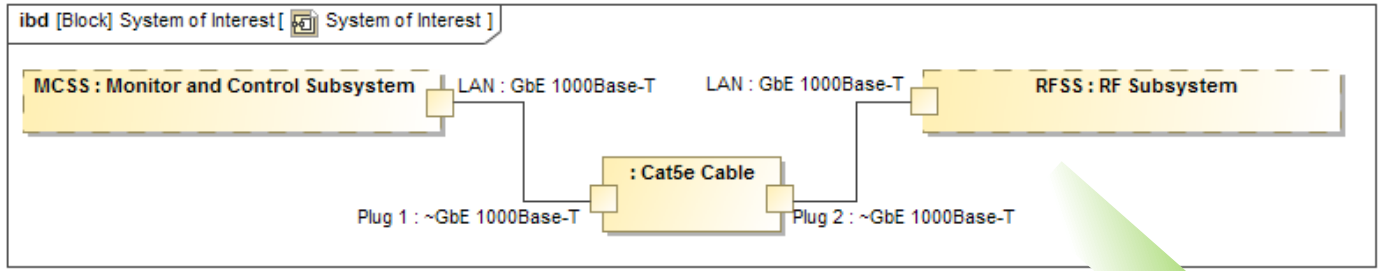
- Common Standard Interfaces
  - IEEE 802.x
  - MIL-STD-1553
  - RS-232C

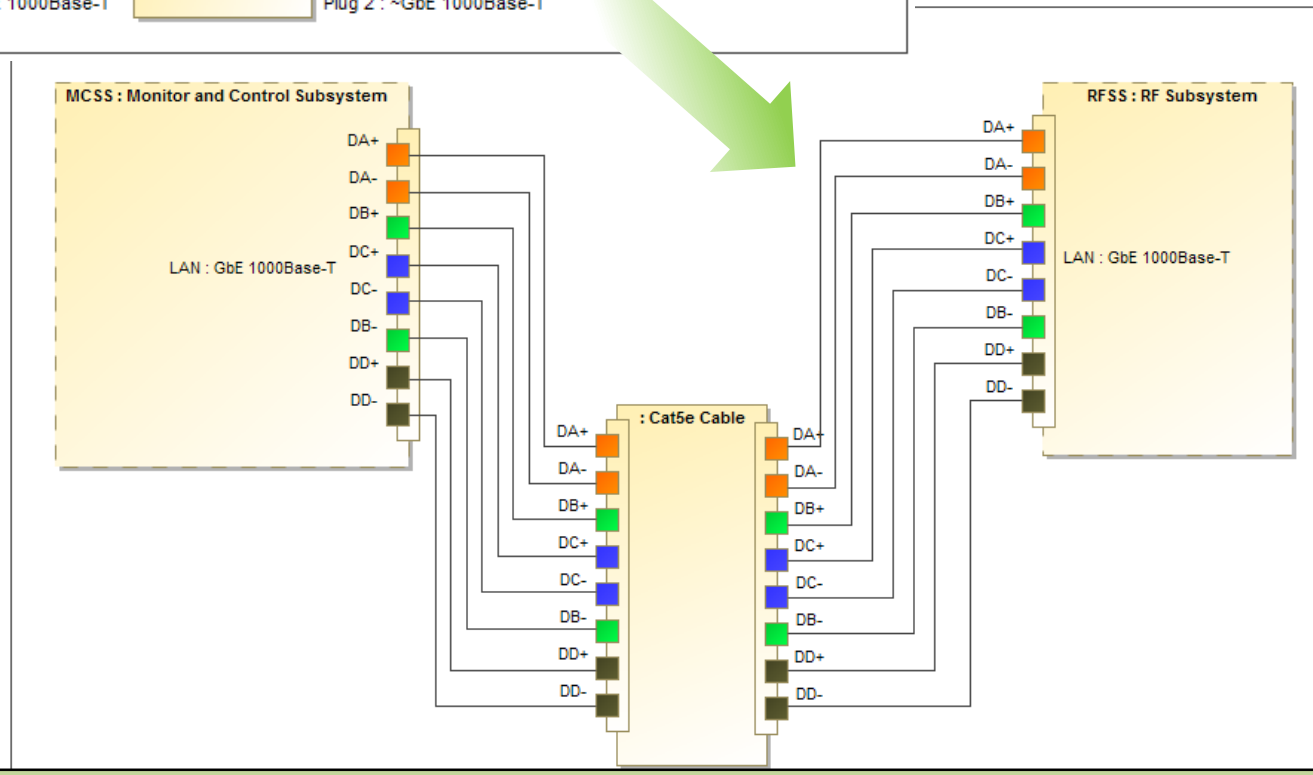
Typical MBSE Approach for Modeling Interfaces



Pin	GbE
1	DA+
2	DA-
3	DB+
4	DC+
5	DC-
6	DB-
7	DD+
8	DD-

Cat5E Cable T568B Standard Pin-out





- Standard pin-out and characteristics
- Can be reused throughout projects
- May be included in standard part libraries (provided by third party companies – i.e. Zuken)

Problems with Modeling Non-Standard Interfaces

- System specific pin-out
  - Want to use standard (COTS) connector shells with a unique system specific pin-out
- System specific signal allocations
  - Interface may have unique signal constraints / link impairments

Approach to Non-Standard Interfaces

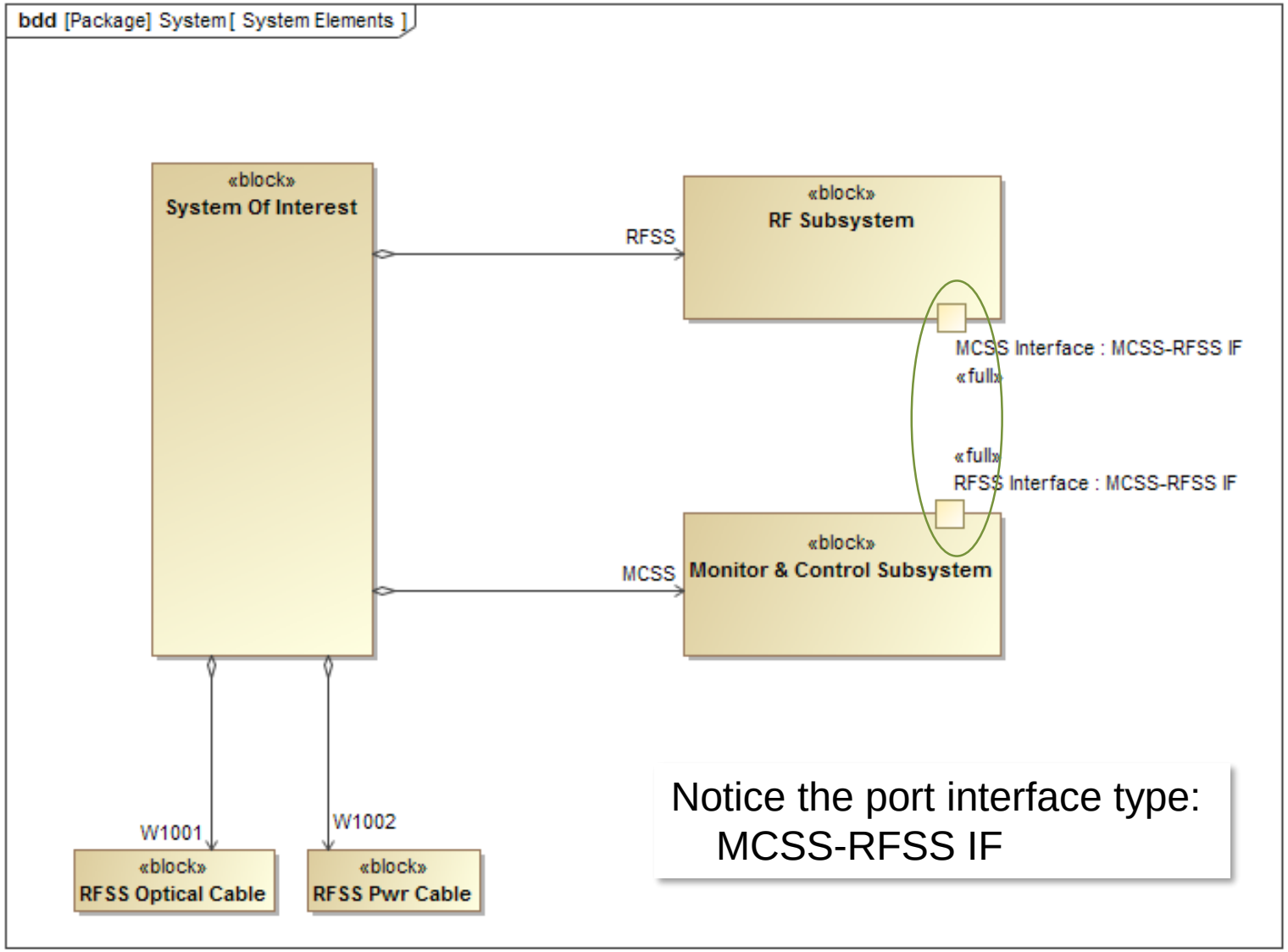
Modeling Arbitrary Signals and Pin-outs

- Define the signals as types separate from the connector-pin definition
- Assign the signal elements to the pins using a SysML dependency association with a unique <<Over>> stereotype
  - The <<Over>> stereotype described in: ‘A modeling pattern for layered system interfaces’ by Peter M. Shames, Marc A. Sarrel
    - http://www.omgsysml.org/A_modeling_pattern_for_layered_system_interfaces-INCOSE%20IS15_paper-sarrel-shames.pdf

Example System Interface

Example system is composed of two subsystems with a non-standard interface

- Want to depict a single ICD that captures all aspects of the subsystem-to-subsystem interface
- This model will also include the internal cabling

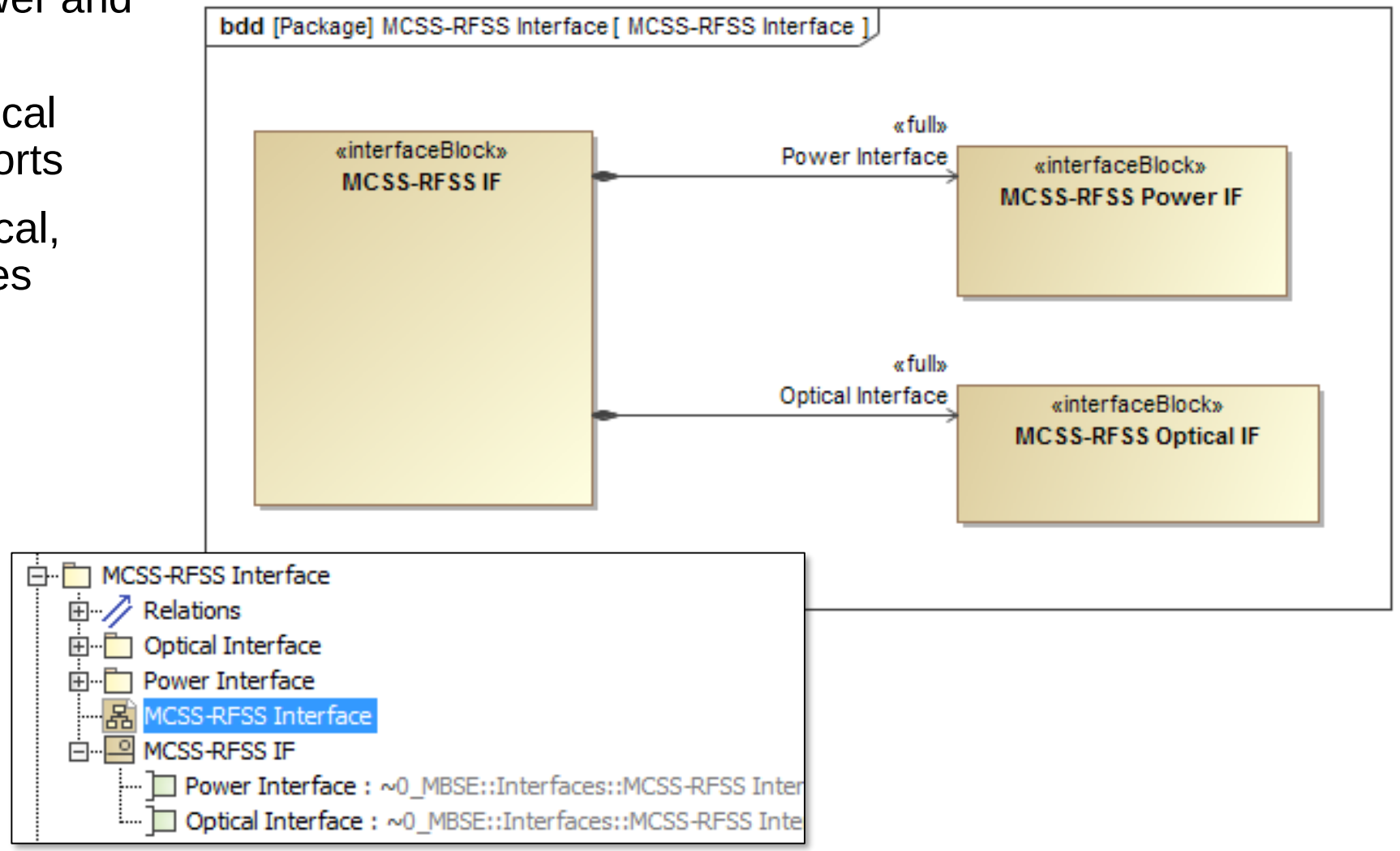


Complete Subsystem to Subsystem Interface Description

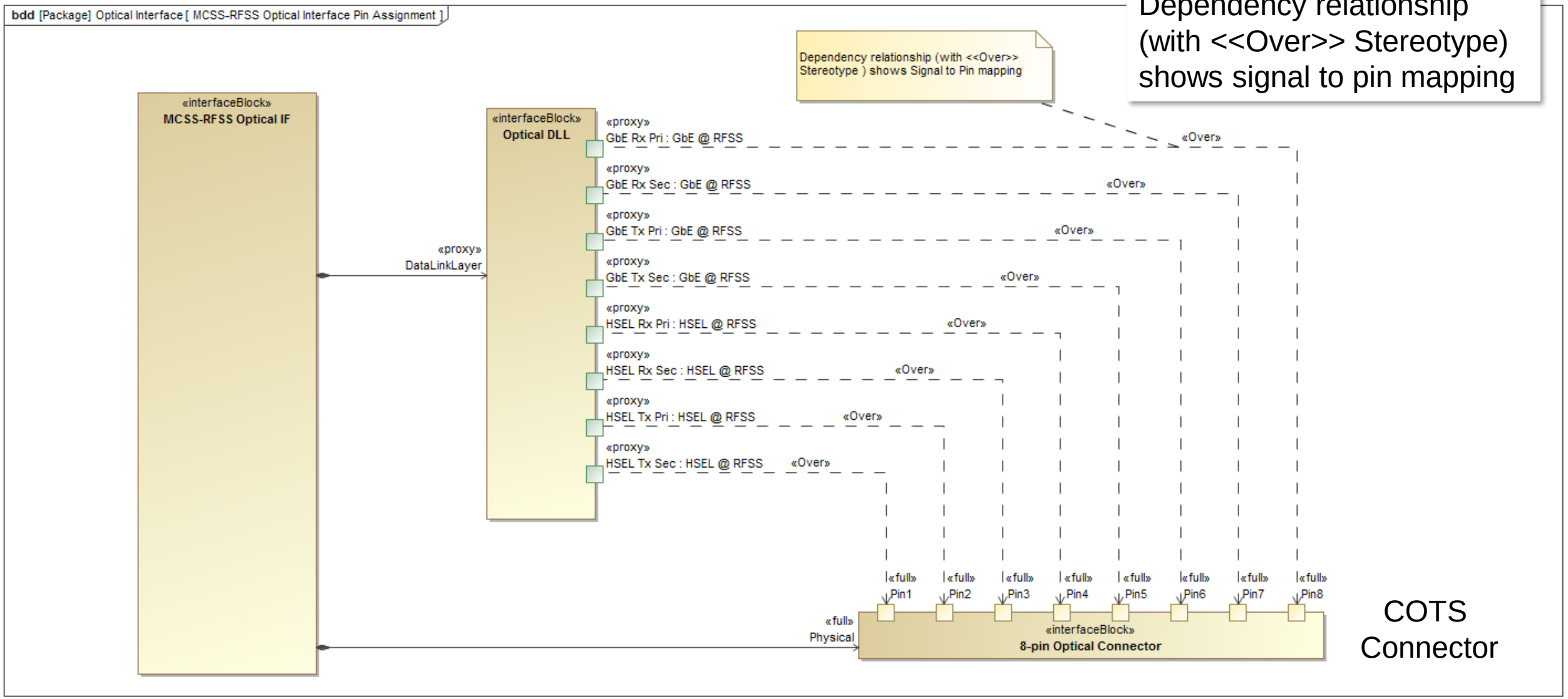
This interface includes a power and optical interface

- Notice the power and optical interfaces are <<Full>> ports

We can also depict mechanical, hydraulic, and other interfaces types as ports



Link Layer Signals Mapped to Connector Pins



Dependency relationship (with <<Over>> Stereotype) shows signal to pin mapping

COTS Connector

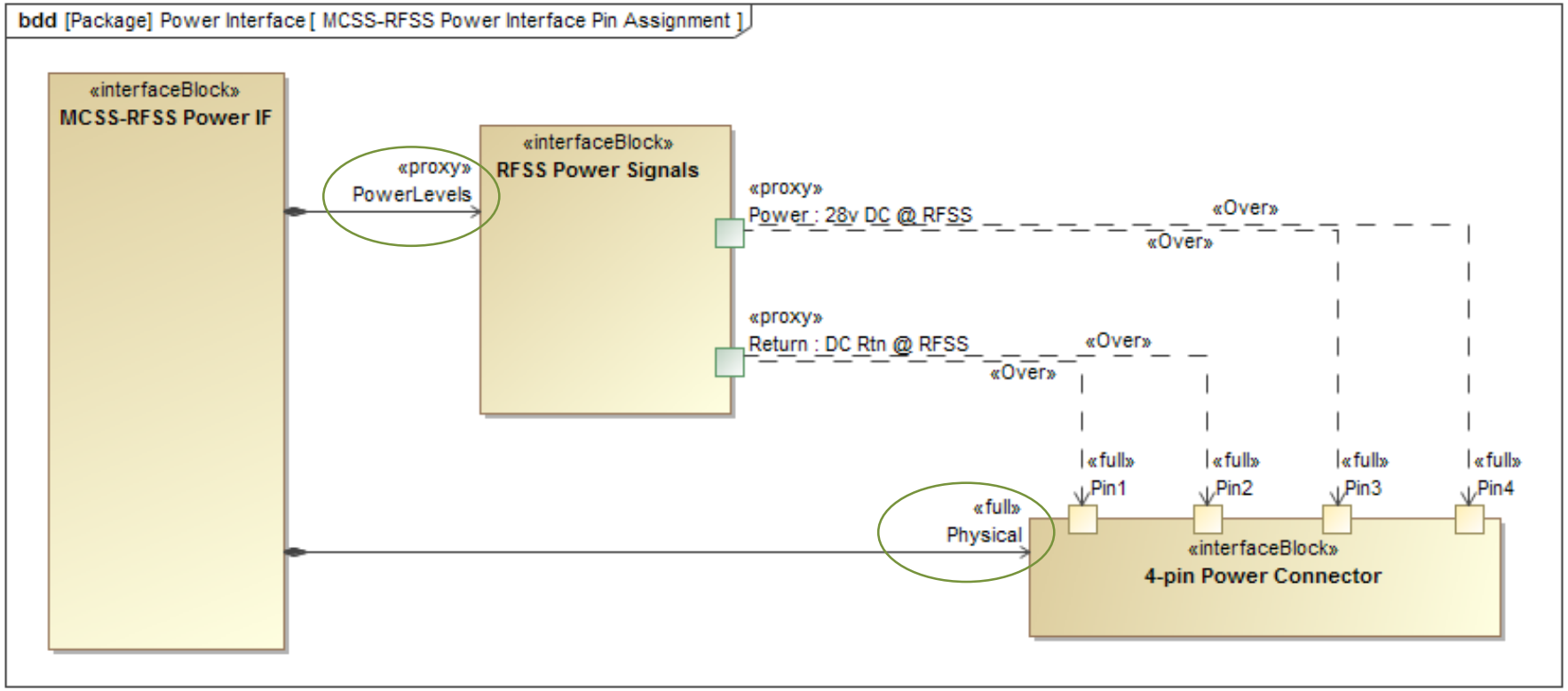
Power and Return Paths Mapped to Connector Pins

Using ***key words*** such as:

- Physical
- DataLinkLayer
- PowerLevels

We can parse the model and create an ICD as a separate document for:

- Version Control
- CDRL



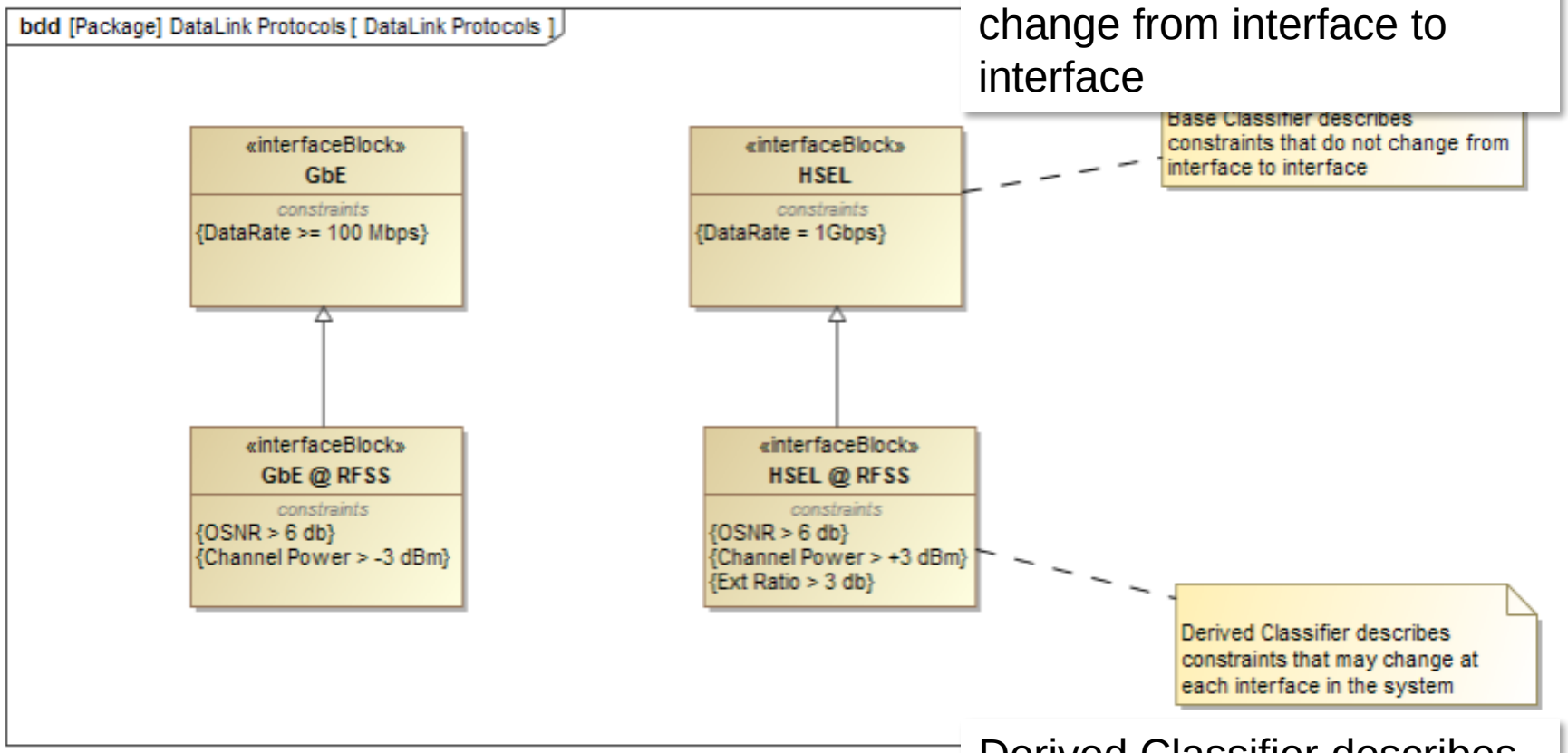
Notice the types:
i.e. ***28V DC @ RFSS*** or ***GbE @ RFSS***
Power and Data types are defined for this particular Interface

Data Types for Specific Interfaces

Constraints may change as the signal travels through the system

Goals:

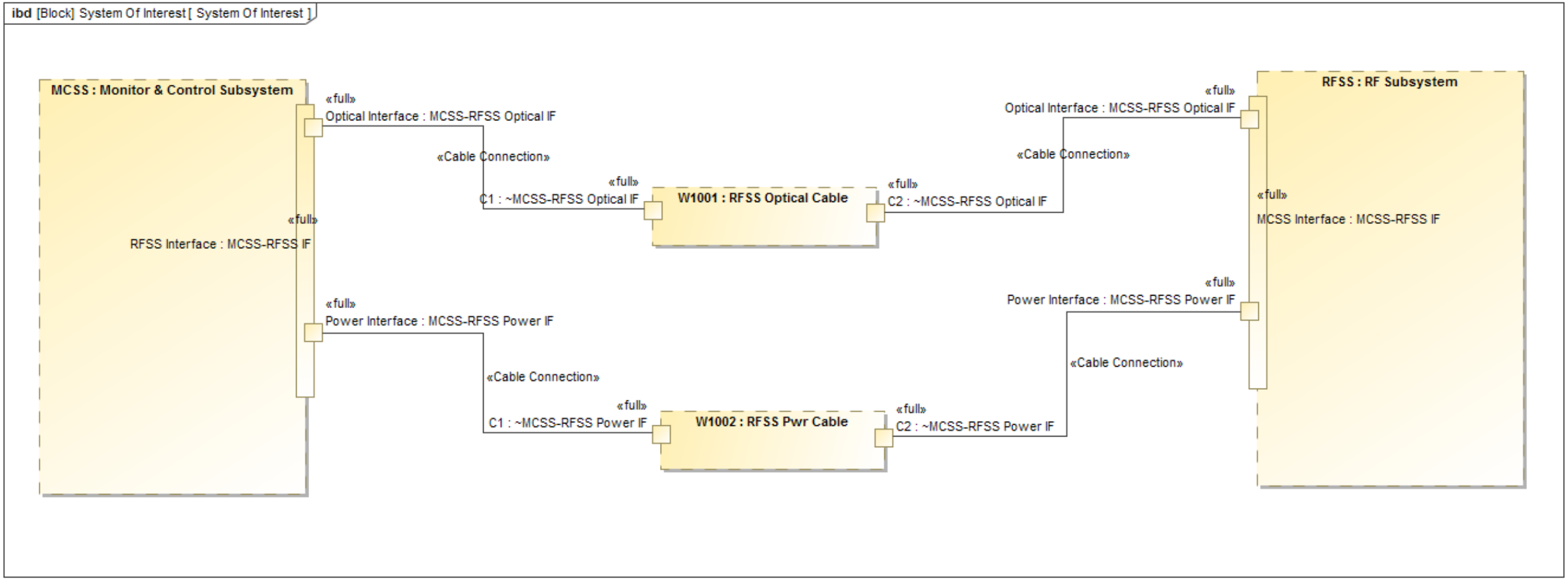
- Depict the unchanging aspects of the signal
- Depict the constraints found at this interface



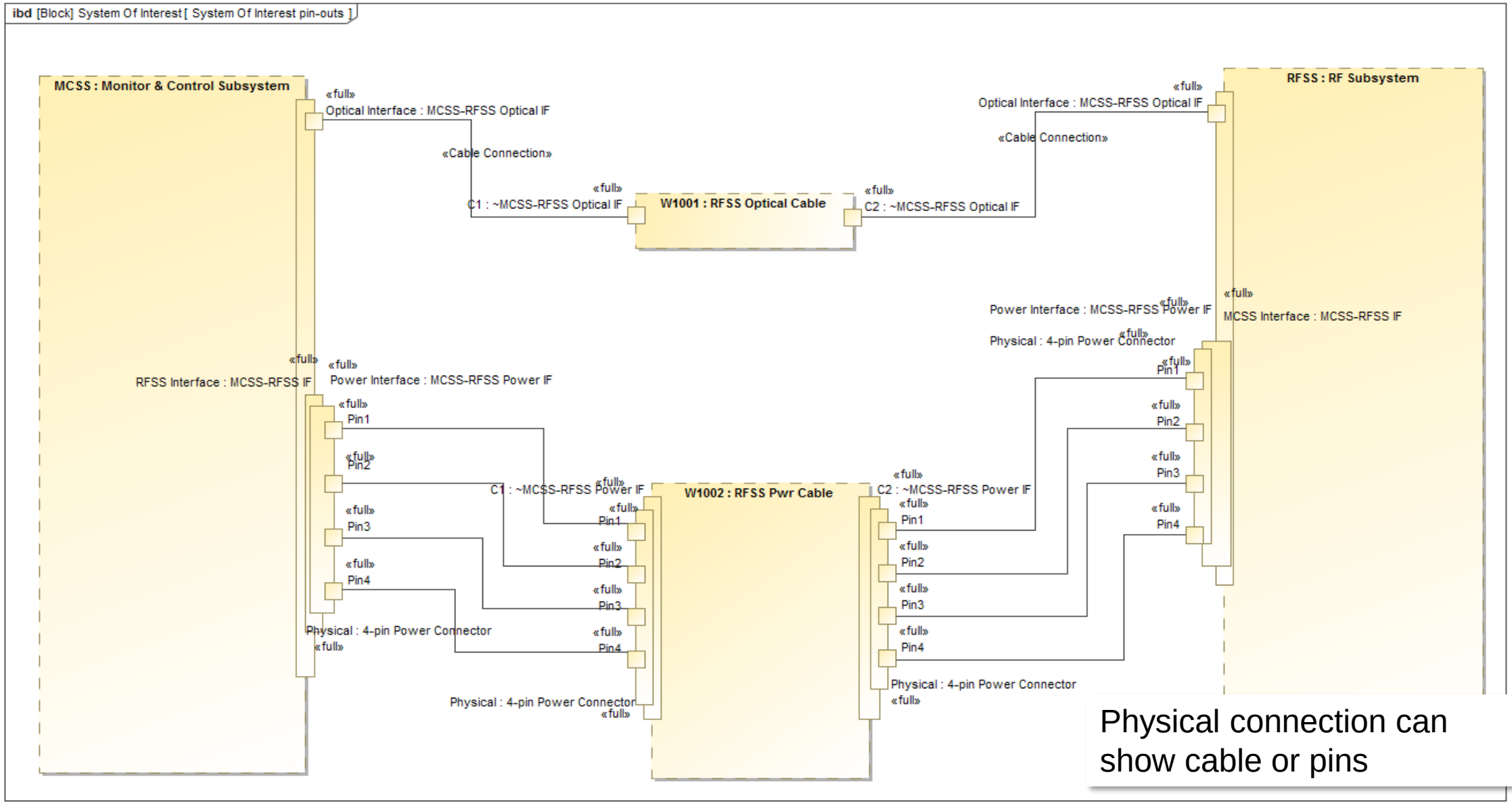
Base Classifier describes constraints that do not change from interface to interface

Derived Classifier describes constraints that may change at each interface in the system

Internal Block Diagram (IBD) w/ Interface



Internal Block Diagram (IBD) w/ Interface Pin-Outs



Physical connection can show cable or pins

Summary/Conclusion

This modeling pattern:

- Allows modelers to create customizable interfaces using existing connectors
  - Flexibility to assign system specific pin-outs
- Allows modelers to assign system specific signal characteristics
  - Flexibility to add signal constraints / Link impairments
- Facilitates creating link budgets by having Interface constraints
- Create complete and detailed IBDs that will facilitate digital handoff to CAD
  - Cable drawings
  - Cable labels
  - Wiring diagrams
- Can create a generic non-standard interface design template (reference model) to be reused throughout the model/organization

Design patterns provide a reusable, recognizable solution to engineering activities