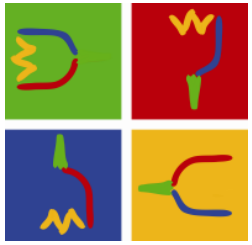


Telescope systems modelling

June, 15th 2008

Robert Karban

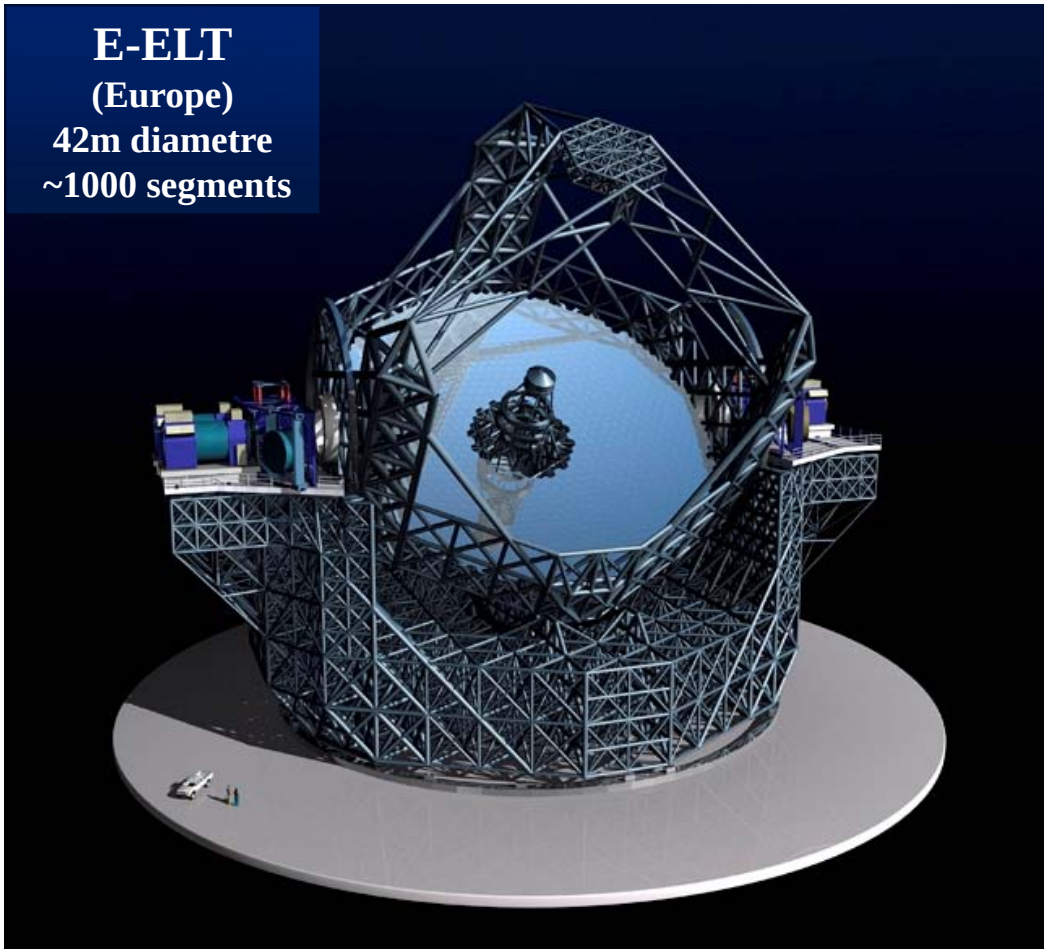
representing the SE^2 team

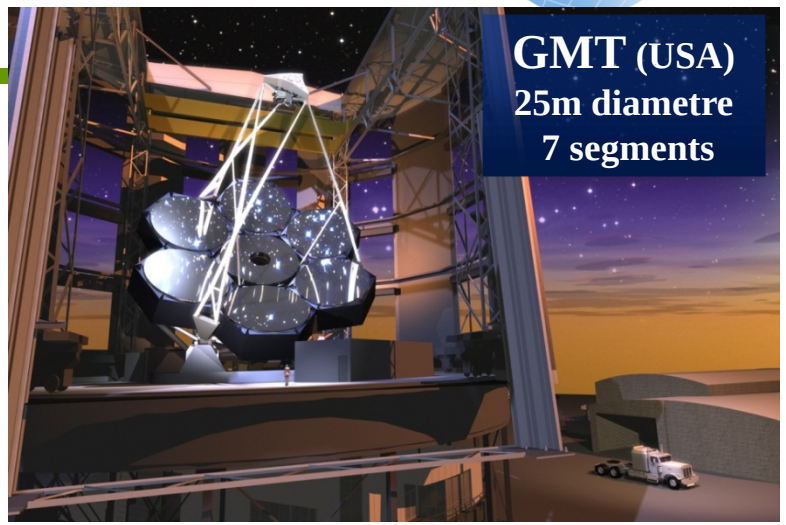
About SE^2

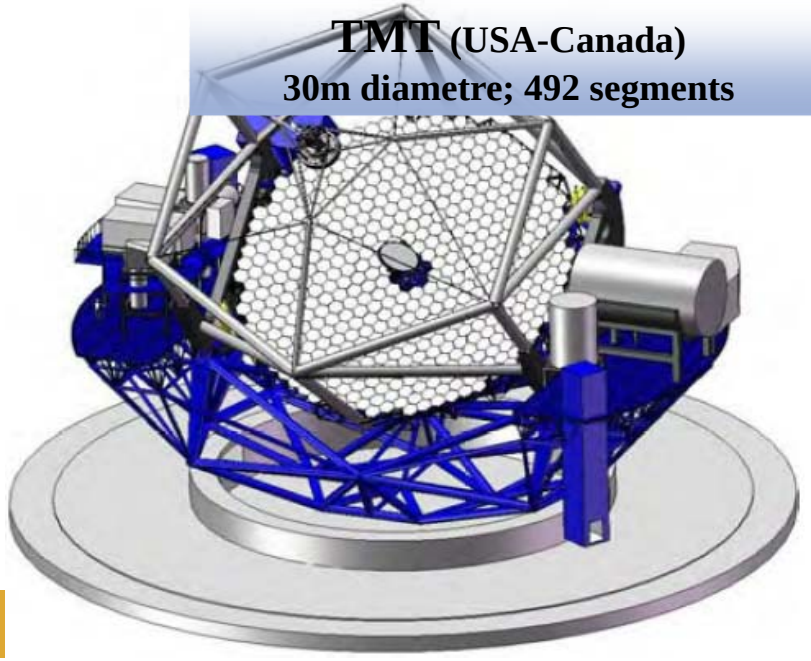
- Collaboration between the European Southern Observatory (ESO) and German Chapter of INCOSE (GfSE)
- Access to a high-tech project, the Active Phasing Experiment (APE).
- The team members are:
  - Robert Karban (ESO)
  - Andreas Peukert (TU Munich)
  - Tim Weilkiens (oose)
  - Rudolf Hauber (HOOD)

Phasing of ELTs

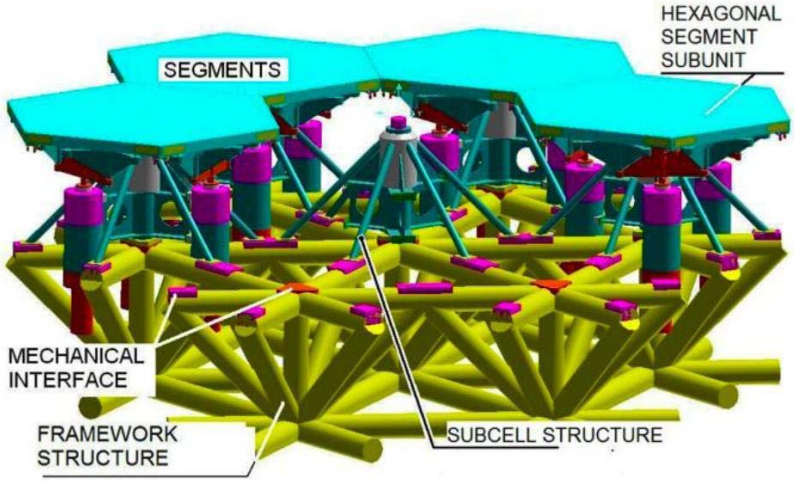
INCOSE
International Council on Systems Engineering

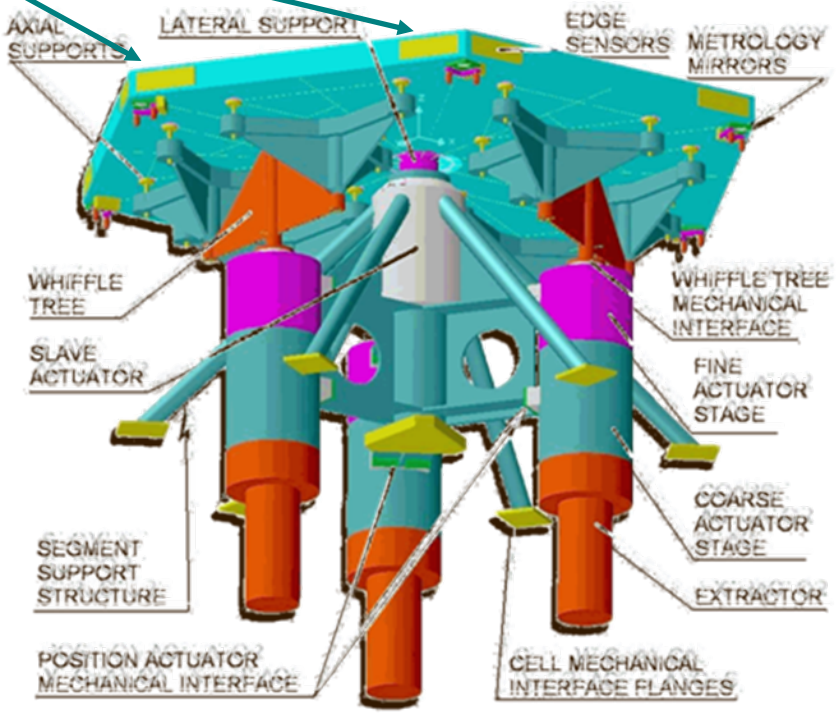






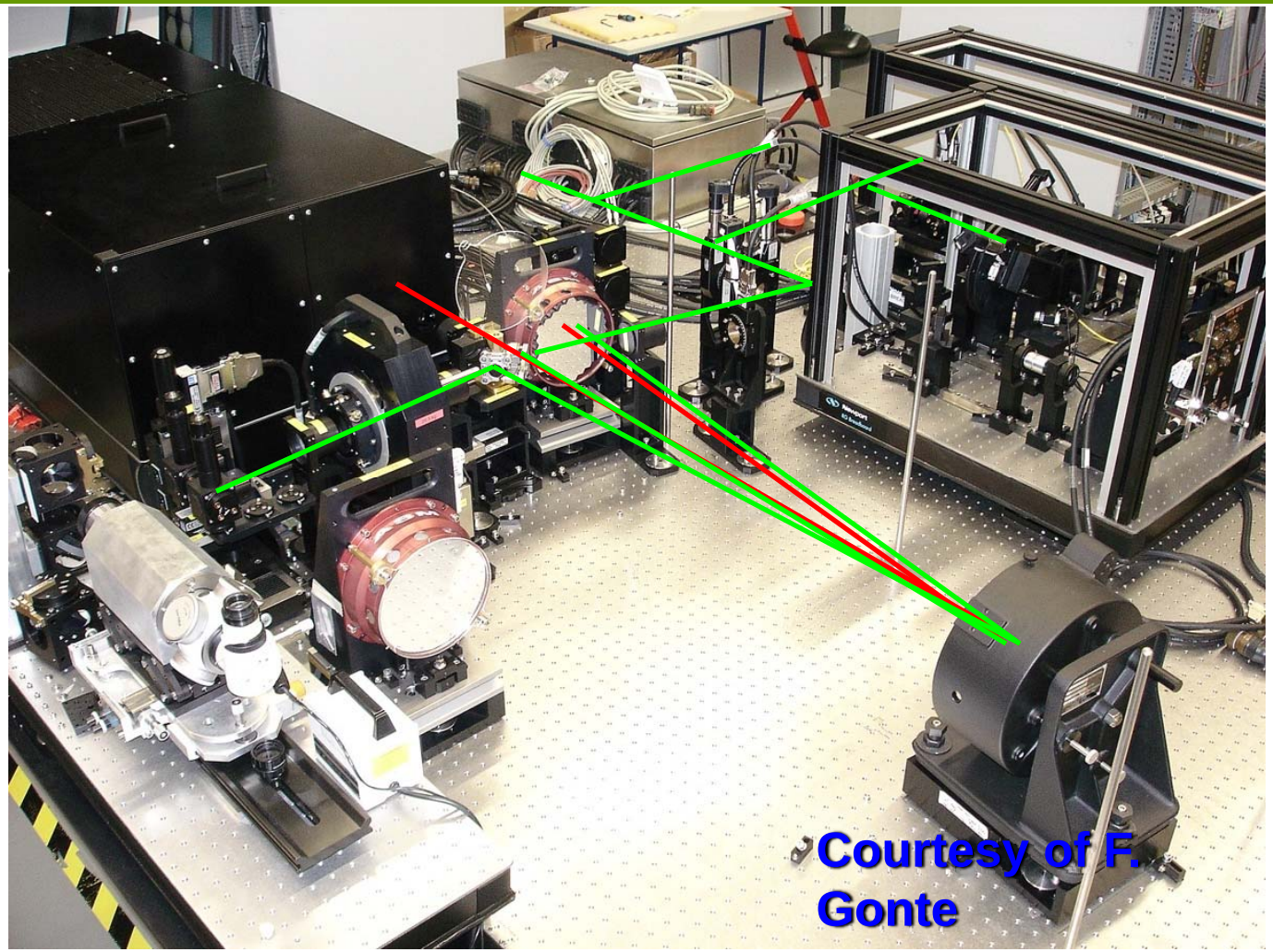
Edge Sensors



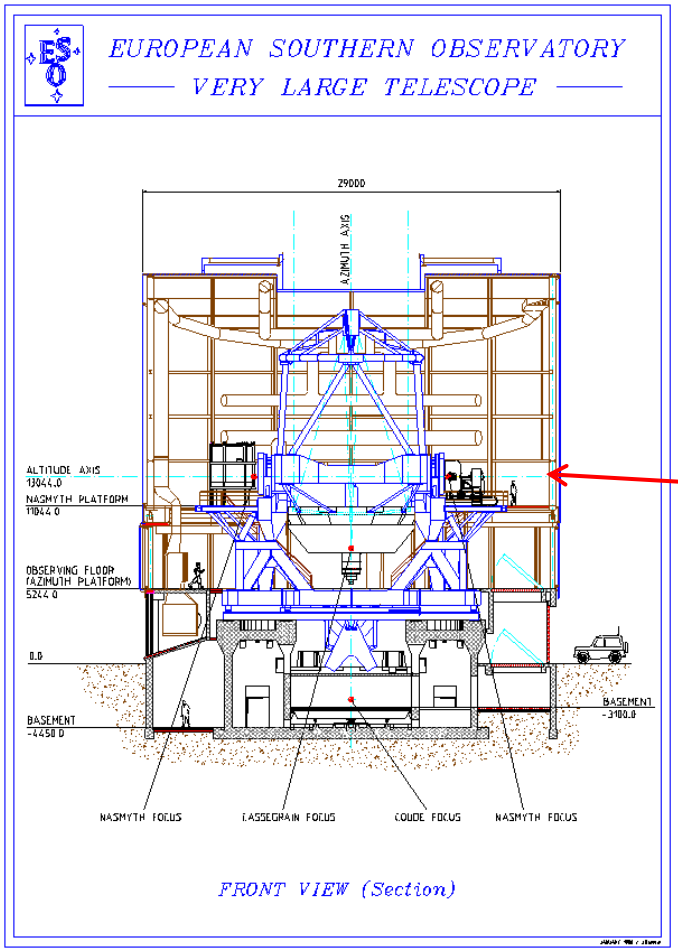


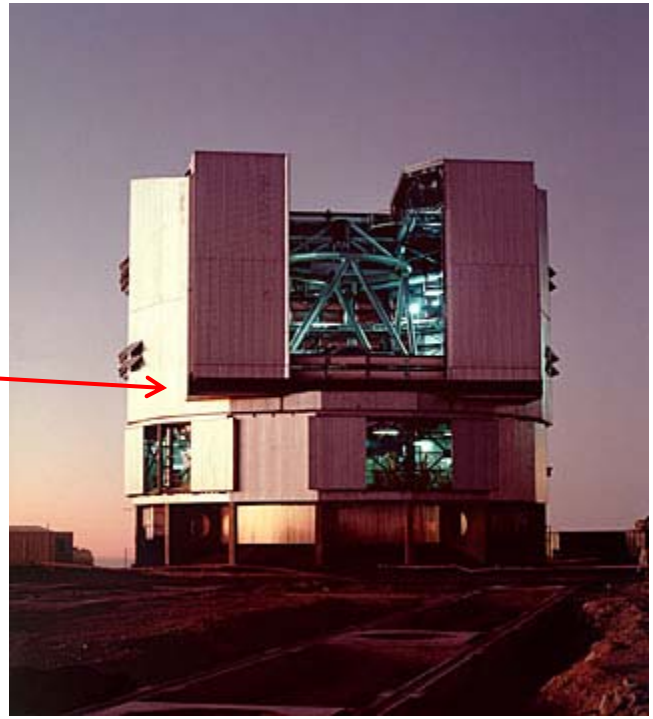
Detect nanometers of phasing error in micrometers of turbulence with Phasing Wave Front Sensors (~20 nm RMS)

Phasing of ELTs and APE



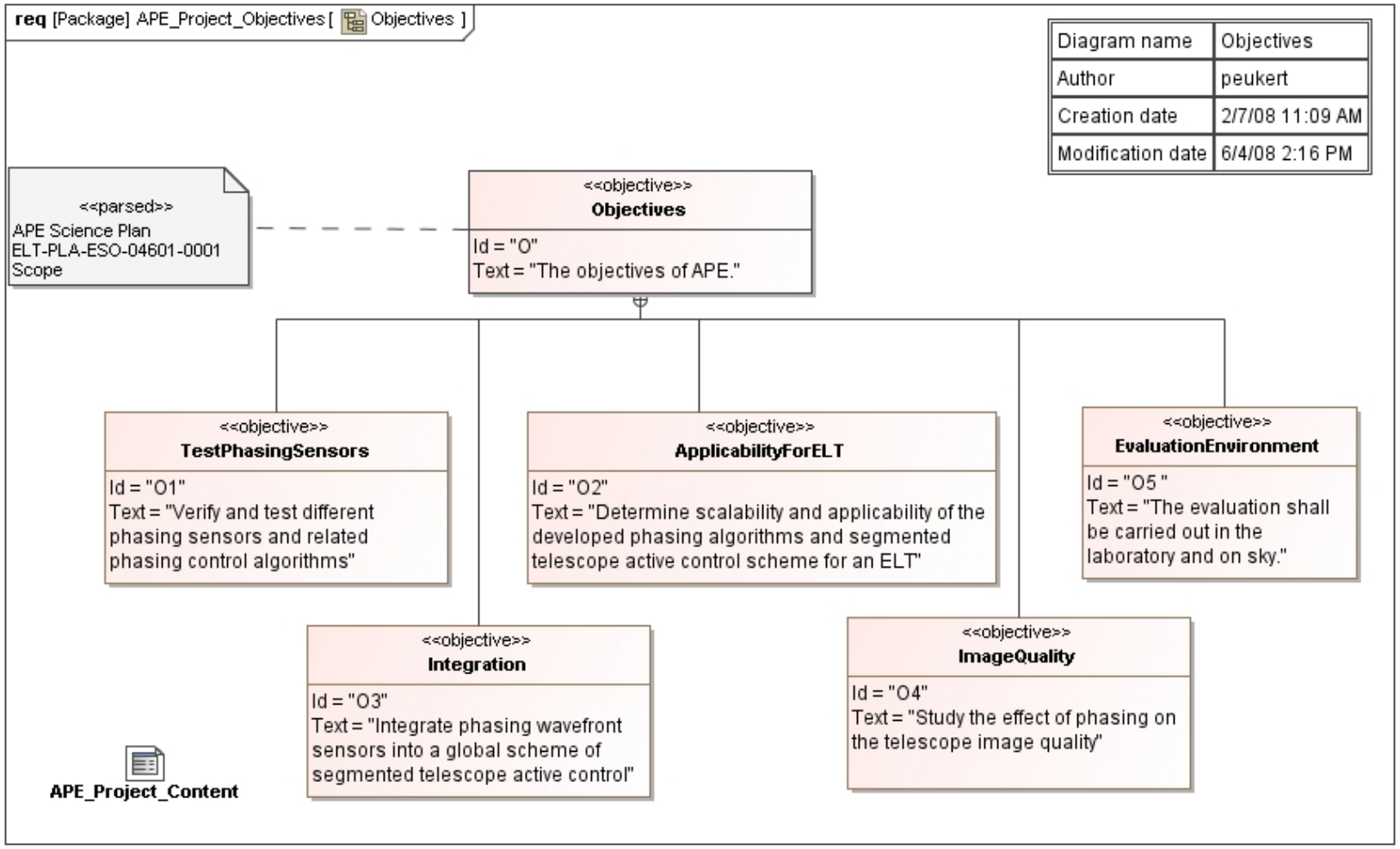
Very Large Telescope



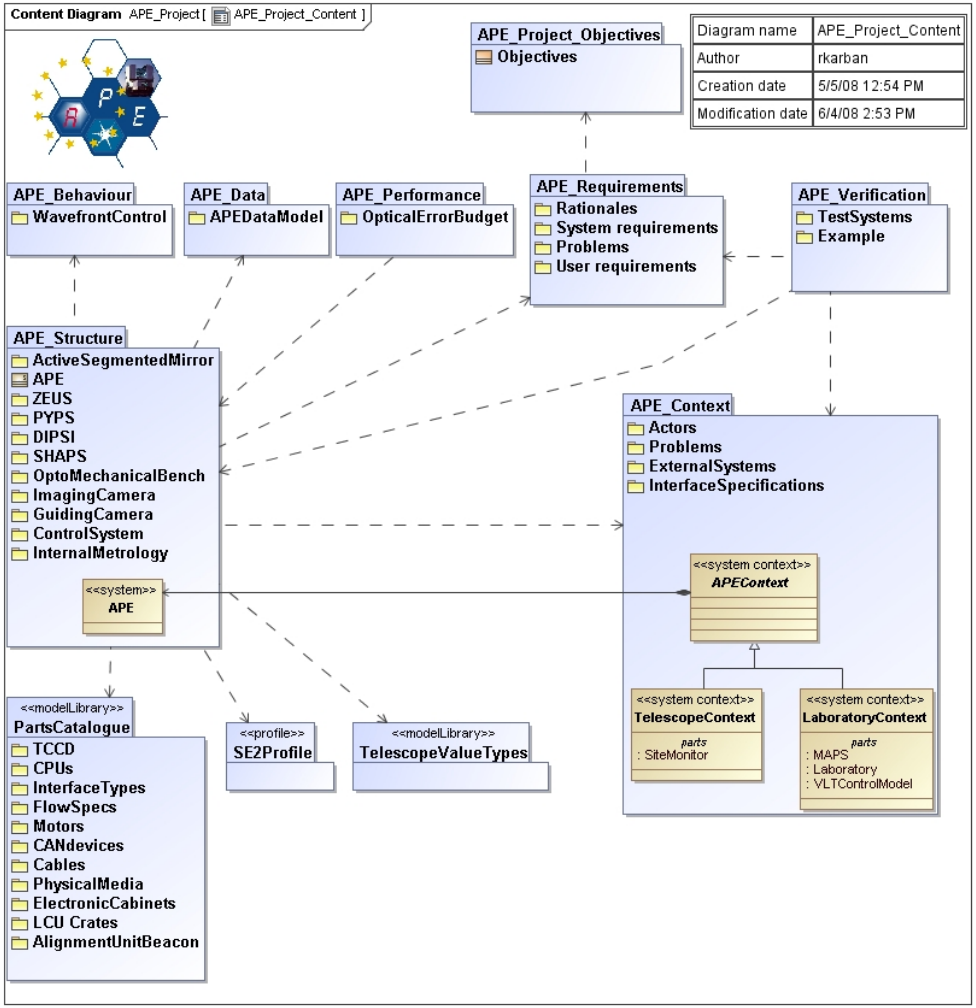


APE will be installed at the telescope in the Chile desert.

The APE project



System Overview



SE^2 goals

- Provide examples of SysML, common modelling problems and approaches:
  - ➔ Build a comprehensive model of the system APE and additional supporting models as elaborate example for all three aspects
- Provide guidelines for modelling a system with SysML resulting from experiences during project
  - ➔ Establish a modelling FAQ to support consistent modelling results (for this and future projects)
- Demonstrate that SysML is an effective means to define common concepts
- Demonstrate that a SysML model enhances traceability

What have we been able to achieve?

Deliverables: Modelling FAQ

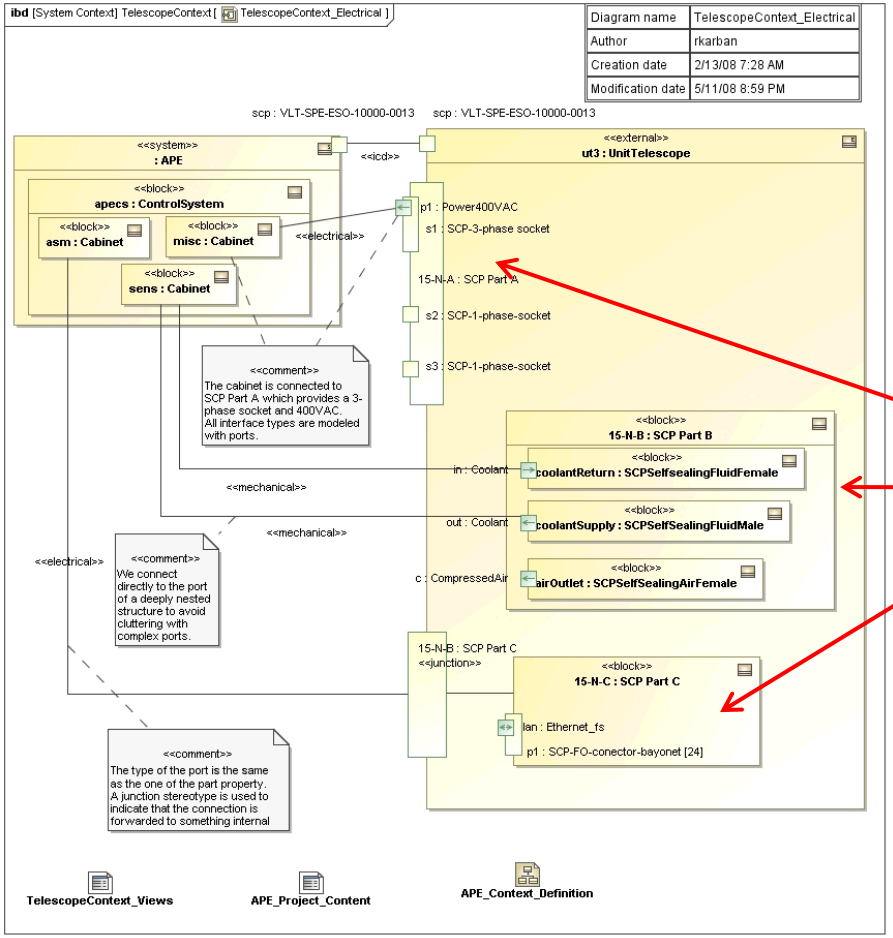
- (Exemplary) content of modelling FAQ:
  - Identification of necessary system models, aspects and views
  - Guidelines for the use of modelling elements (e.g. use of ports and flows)
  - Guidelines for interface modelling
  - Allocation strategies
  - Guidelines for modeling the system structure
  - Guidelines for the definition of system hierarchies
  - Heuristics for using requirements relationships (e.g. derive, refine)
  - Naming conventions for modelling elements (e.g. diagram names, block names)
  - Style and layout issues

Deliverables: System model

- Three major model parts:
  - Actual system model: APE (with all mentioned system aspects)
  - Catalogue model: standard parts, library of block prototypes
  - Modelling profile: additional stereotypes
- Main characteristics:
  - Scalable model structure and organisation
  - Includes model annotations, external references
  - Various examples of ports and flows to model interfaces
- Abstraction levels
  - Functional, Structural, Deployment
- Preliminary results are available at mbse.sysmod.de

Solution: System model

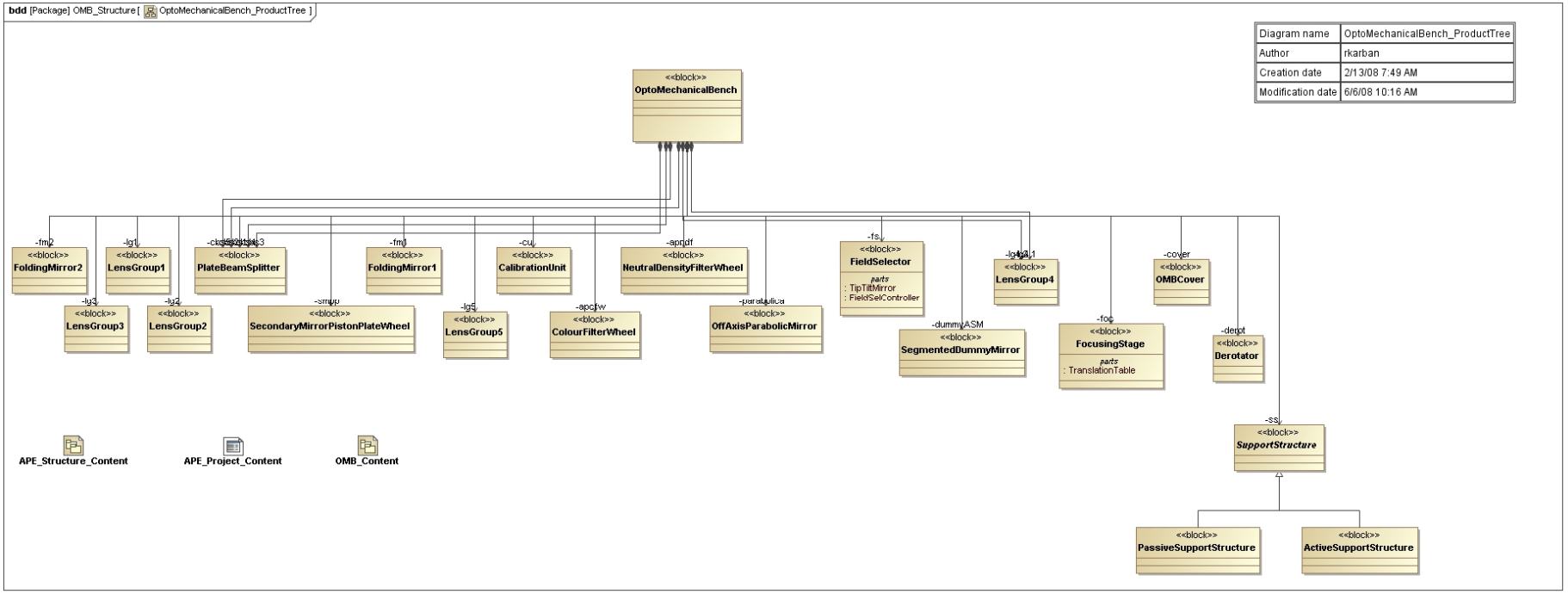
Example for system context



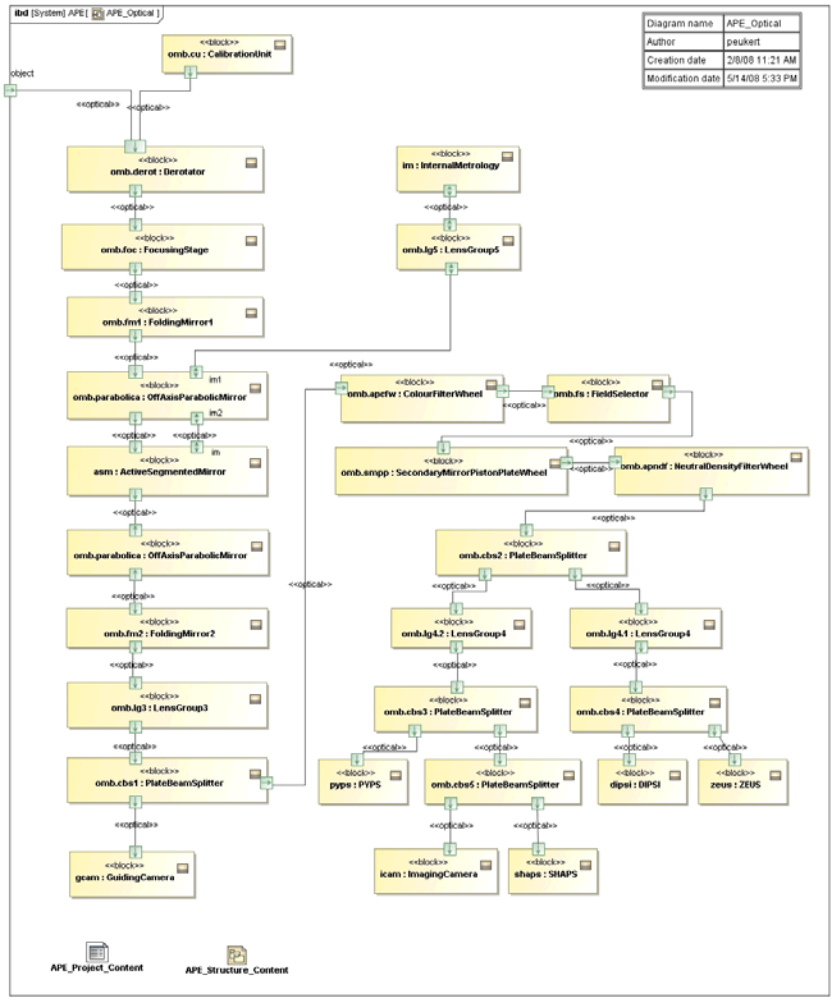
3 modeling approaches for interfaces

System model: High Level Structure

Example for system structure: “Product tree” of Opto-Mechanical Bench

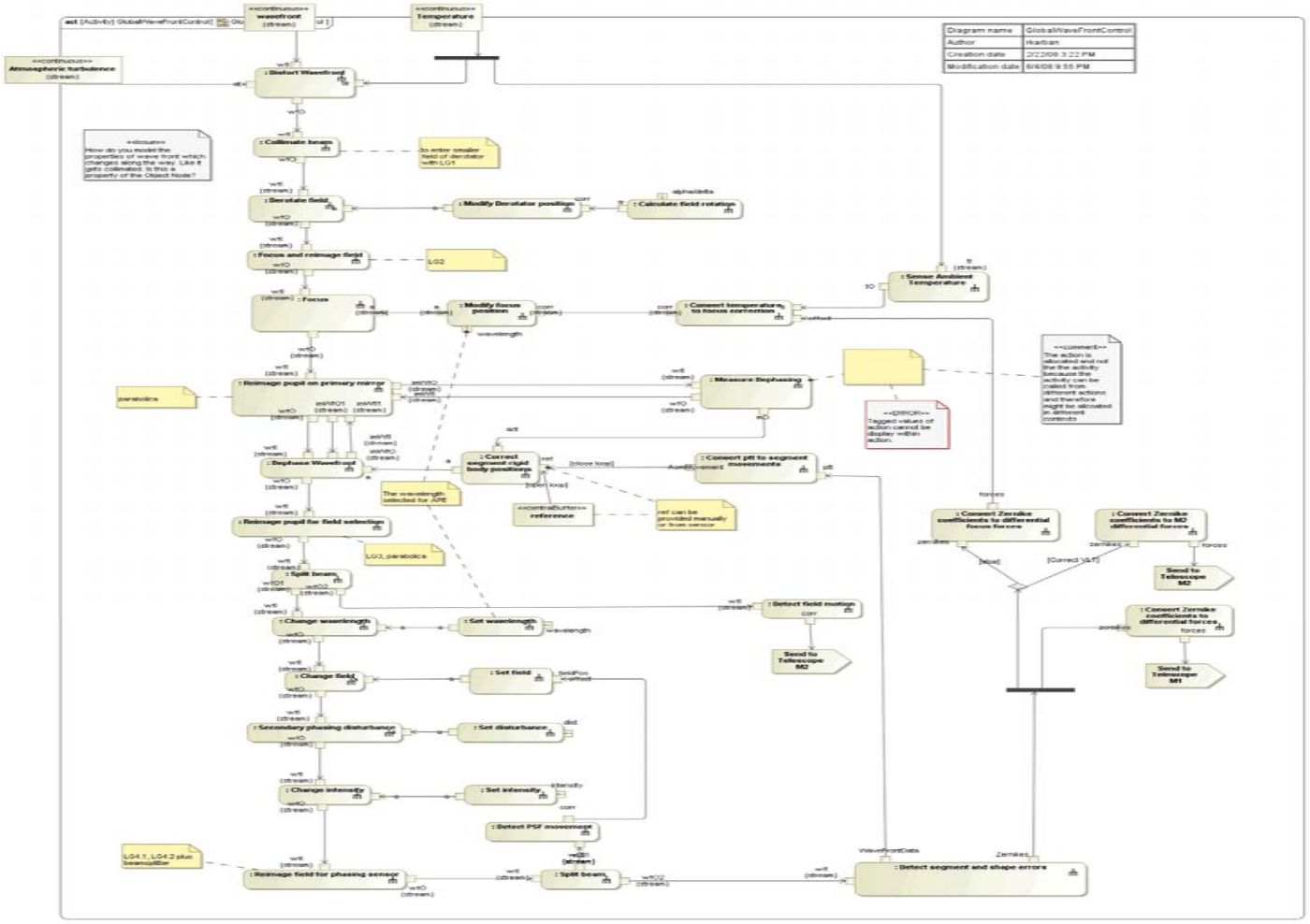


System model: Detailed Structure



Example for refined system structure:
“Optical view of APE”

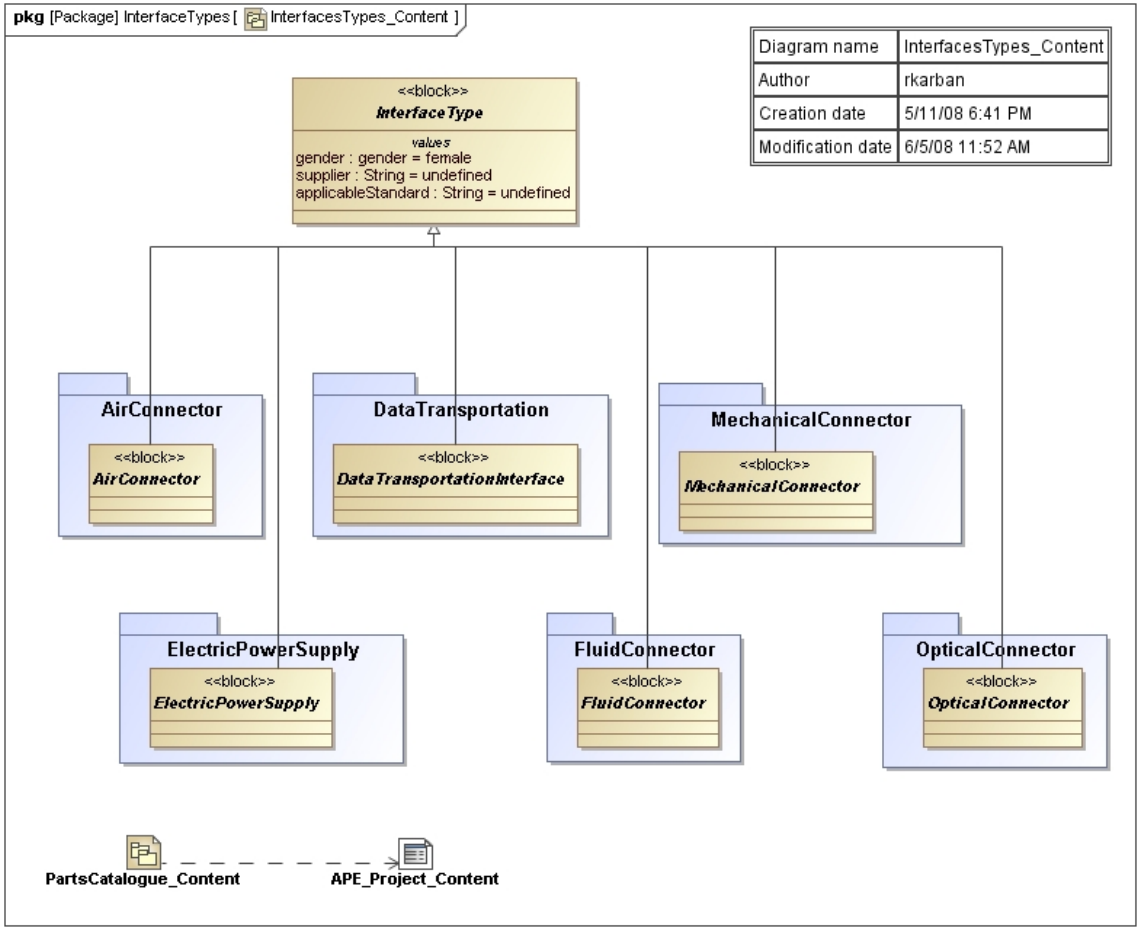
System model: Behavior



Example for system behavior: “Activity”

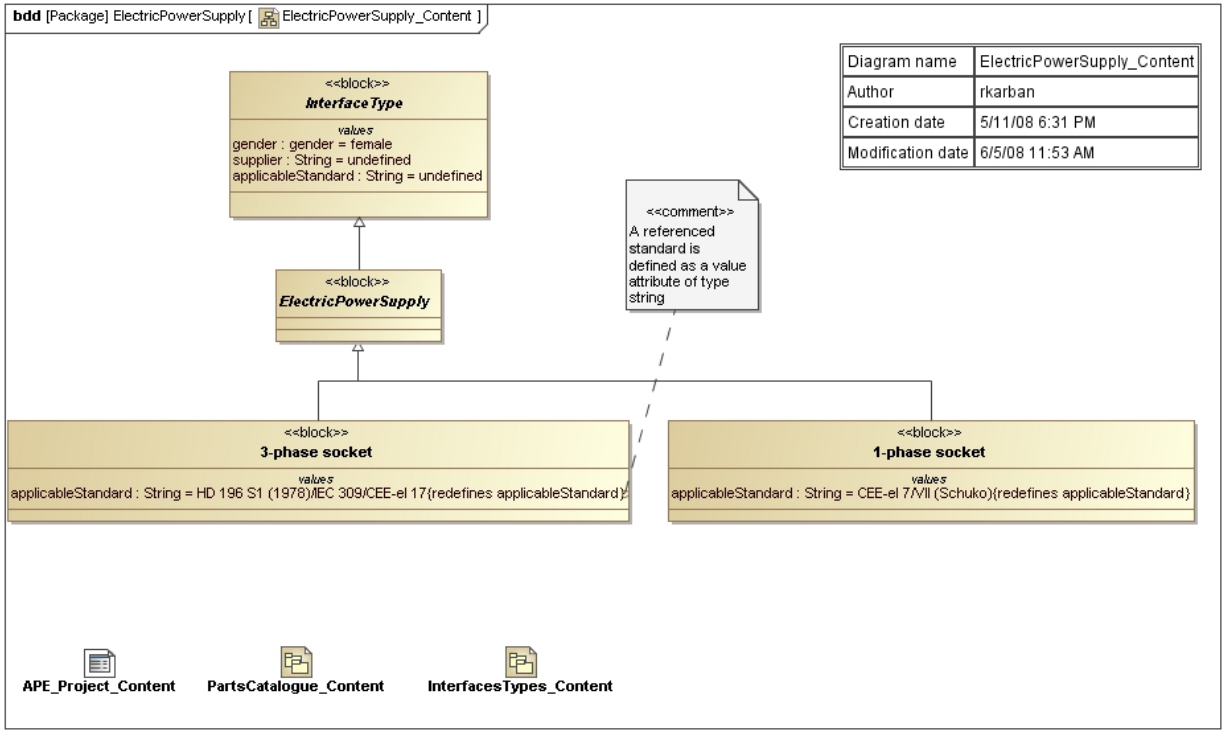
Catalogue model: Abstract types

Example for catalogue:



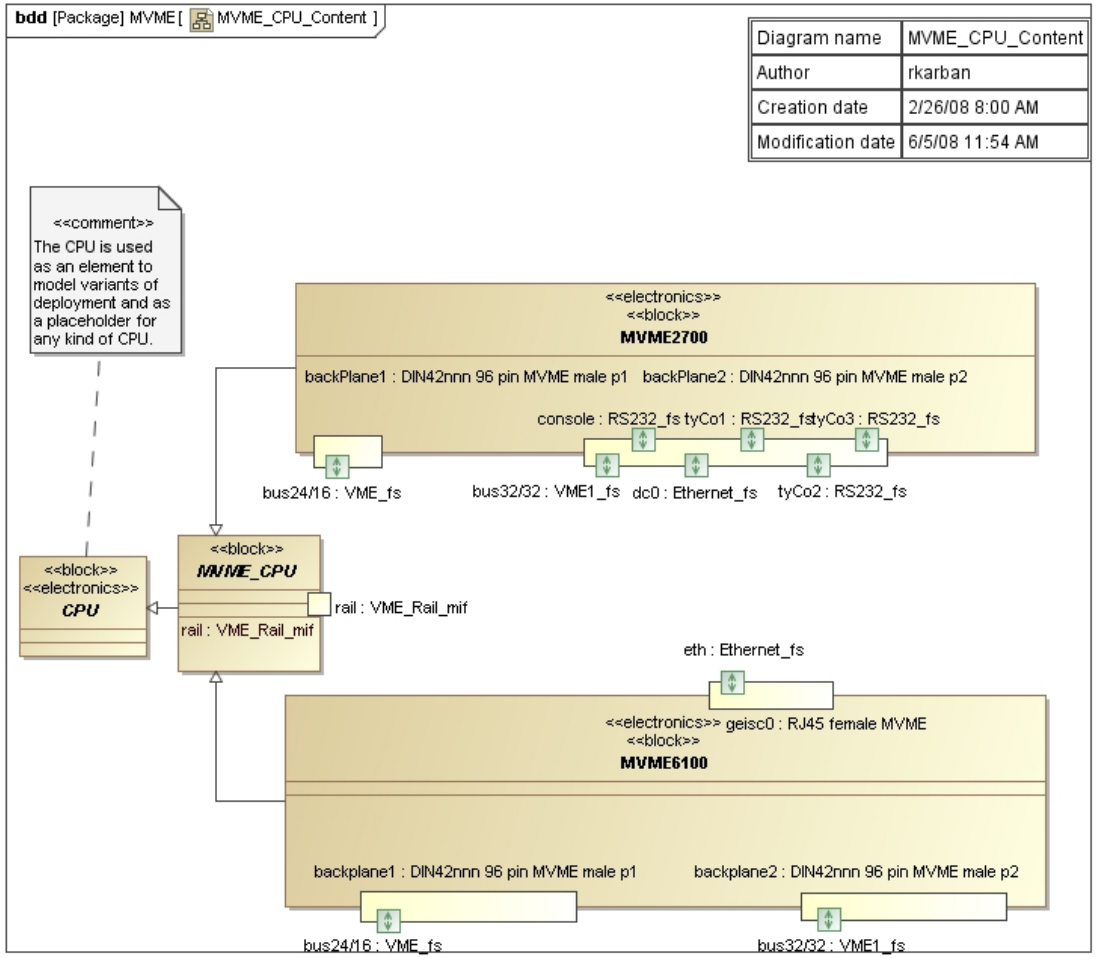
Catalogue model: Concrete types

Example for catalogue: Power Supply Interfaces



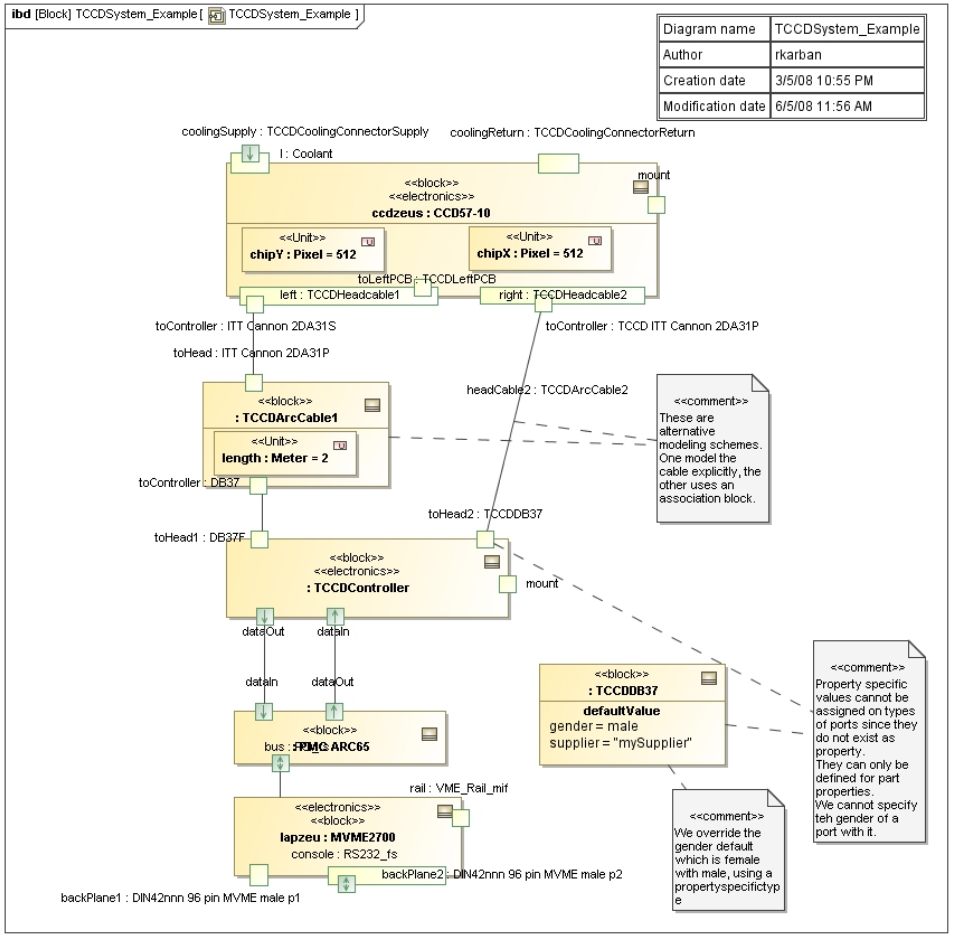
Catalogue model: Type usage

Example for catalogue:
CPU types and different flow port assignments



Catalogue model: Assembling the pieces

Example for a complex catalogue part, a TCCD



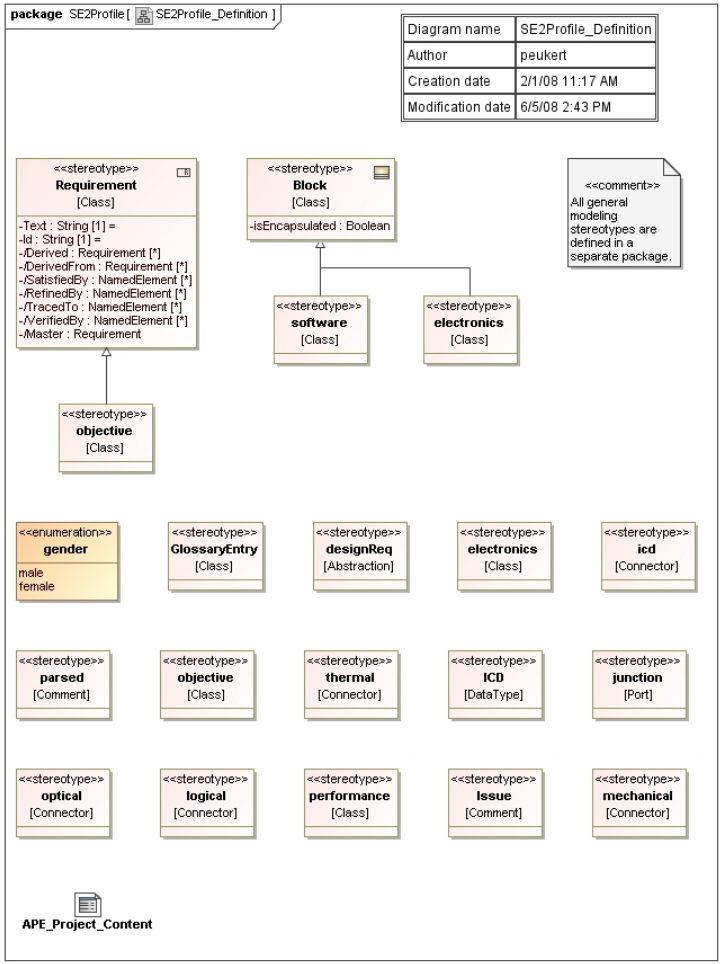
Solution: Traceability

Example for automatic dependency matrix between objective and user requirements:

	UserRequirement...	APE laboratory [...	AtmosphericSensi...	AtmosphericTurb...	CaptureRange [A...	DefocusControl [...	DoubleSegmentat...	EdgeSensorSimul...	EvaluationOfWav...	FinalAccuracy [A...	GlobalAberrations...	IntegrationOfWa...	LimitingStarMagni...	OperationalTime [...	CalibrationTimeOf...	CalibrationTimeO...	MaximumTelesco...	MeasurementTim...	Report [APE::AP...	ResidualPSF [APE...	ScallopingEffect [...	SegmentationErr...	SensorPlatform [...	SimultaneousContr...	TestRequirement...	ClosedLoopMeas...	OpenLoopMeasur...	UT of the VLT [AP...	VerificationOnSky...
APE_Project_Objectives [APE]	1		2	1	1	1	1	1	1	2	1	1	1		1	1	1	1	1	1	1	1	1	1		1	1		2
Objectives [APE::APE_Proj...	↙																												
Objectives [APE::APE_Proj...			2	1	1	1	1	1	1	2	1	1	1		1	1	1	1	1	1	1	1	1	1		1	1		2
ApplicabilityForELT [APE...							↙	↙		↙			↙		↙	↙	↙	↙	↙										
EvaluationEnvironment [...			↙	↙																									↙
ImageQuality [APE::APE...			↙							↙										↙									↙
Integration [APE::APE_...											↙	↙												↙					
TestPhasingSensors [AP...					↙	↙			↙												↙	↙	↙			↙	↙		

Solution: Modelling profile

Example for SE^2 profile:

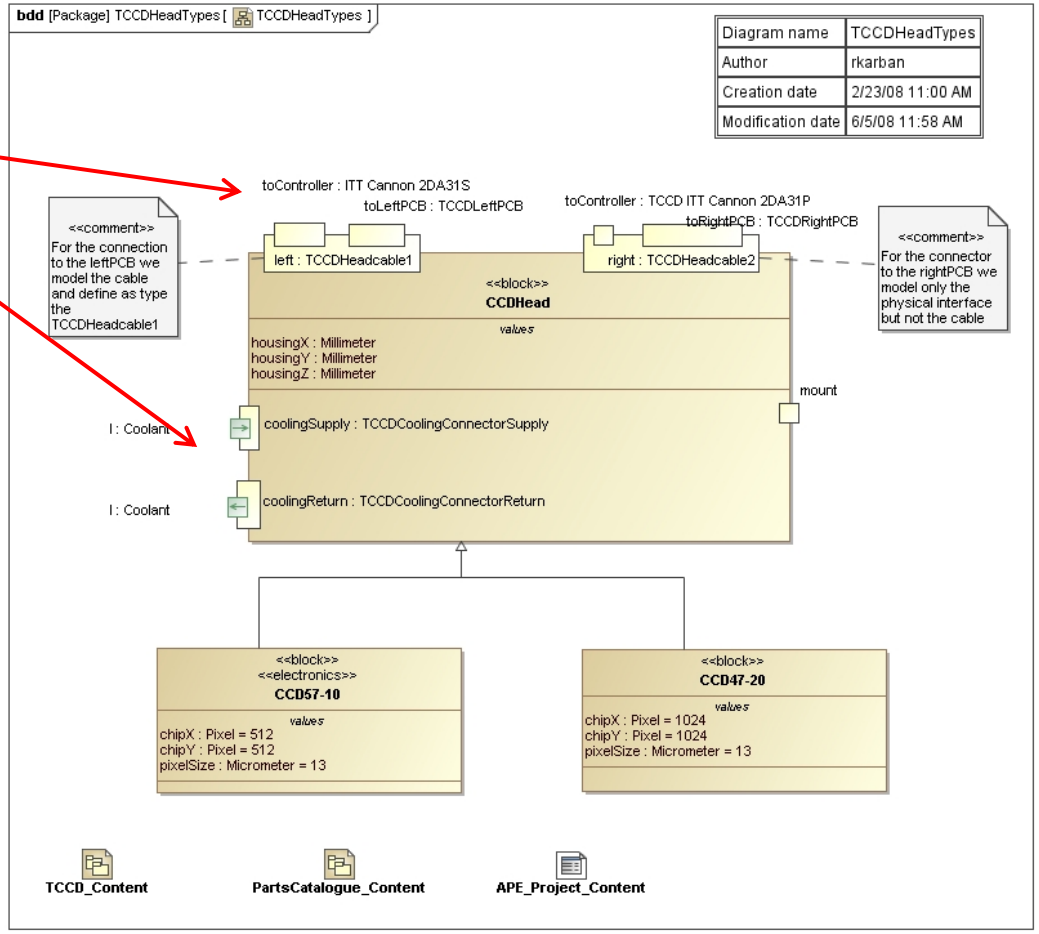


SysML challenges

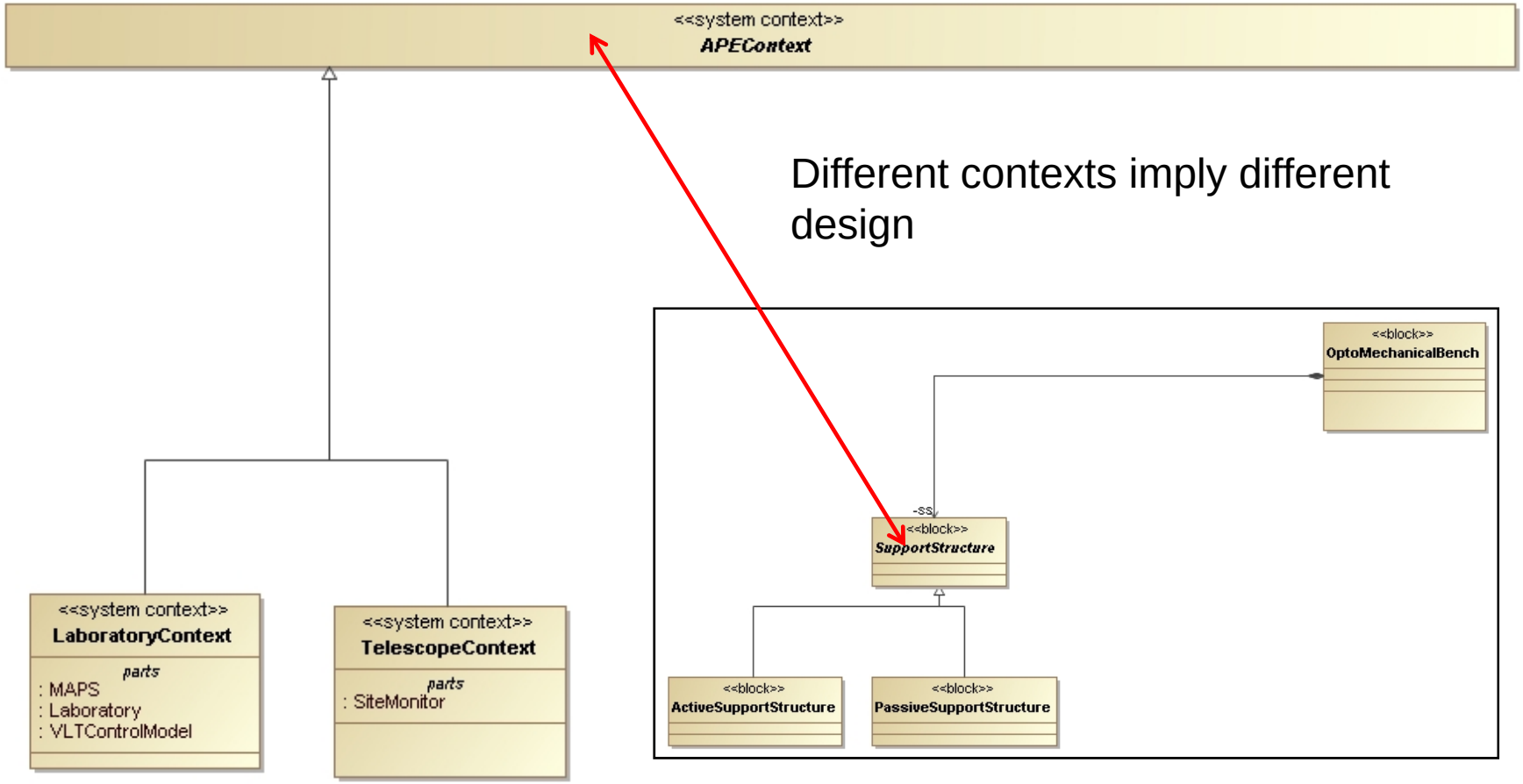
- Combining different aspects with Nested ports
- Variant modeling
- Property specific types
- Different types of interfaces like mechanical, electrical, logical, interface based on a standard document
- Reuse of association blocks
- Defining QoS
- Multi-layer abstraction (like ISO OSI model)
- Mapping activities to blocks

Challenge: Nested Ports

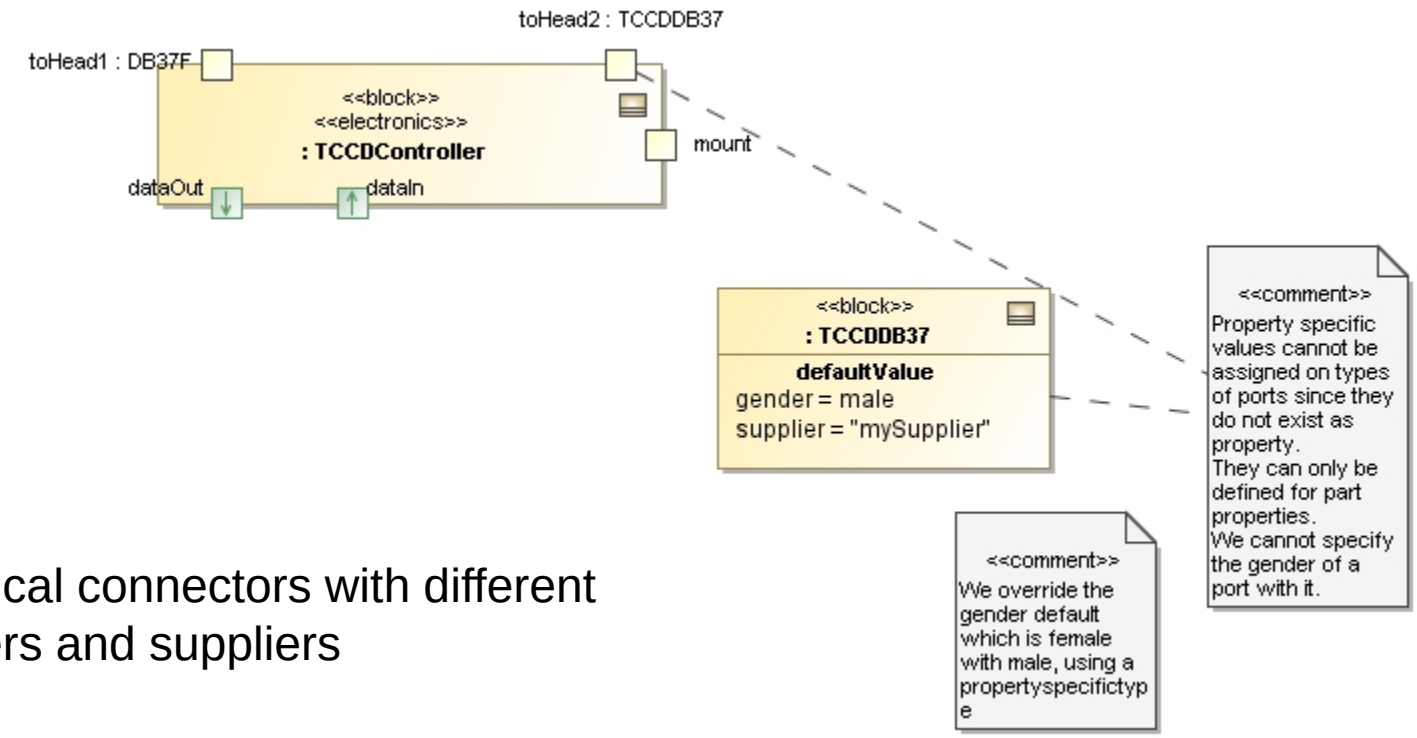
Example for nested ports:



Challenge: Variant modeling

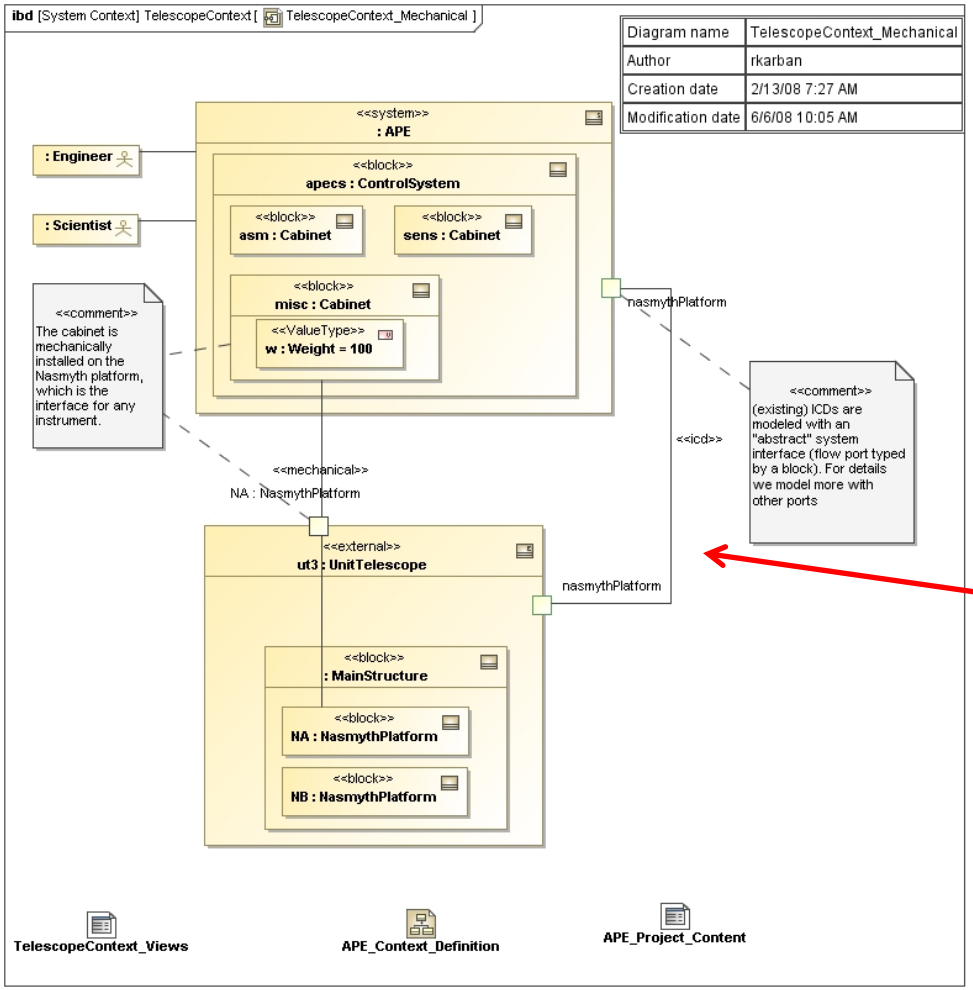


Challenge: Property specific types



Electrical connectors with different genders and suppliers

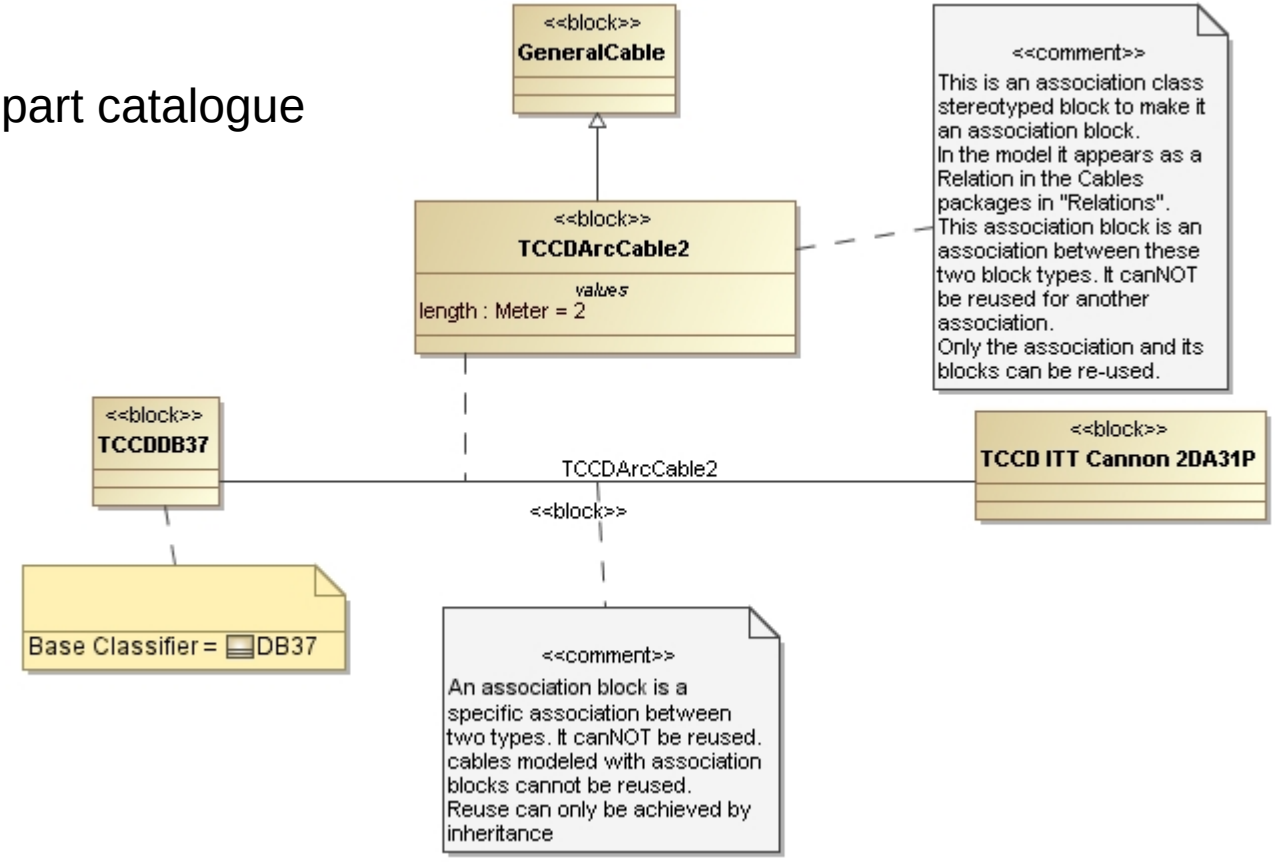
Challenge: Interfaces specified by ICDs



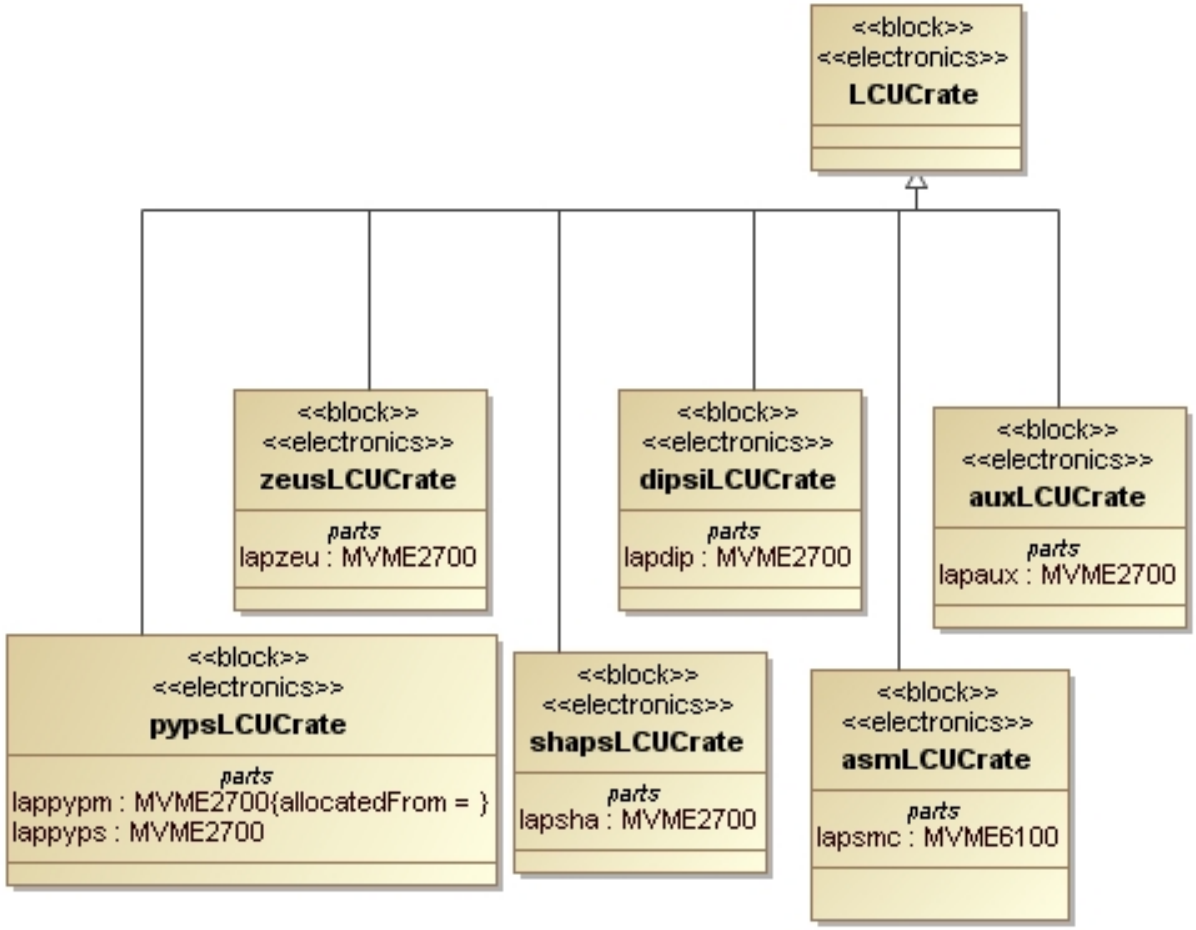
ICD specifies the APE-Telescope interface

Challenge: Re-use of association blocks

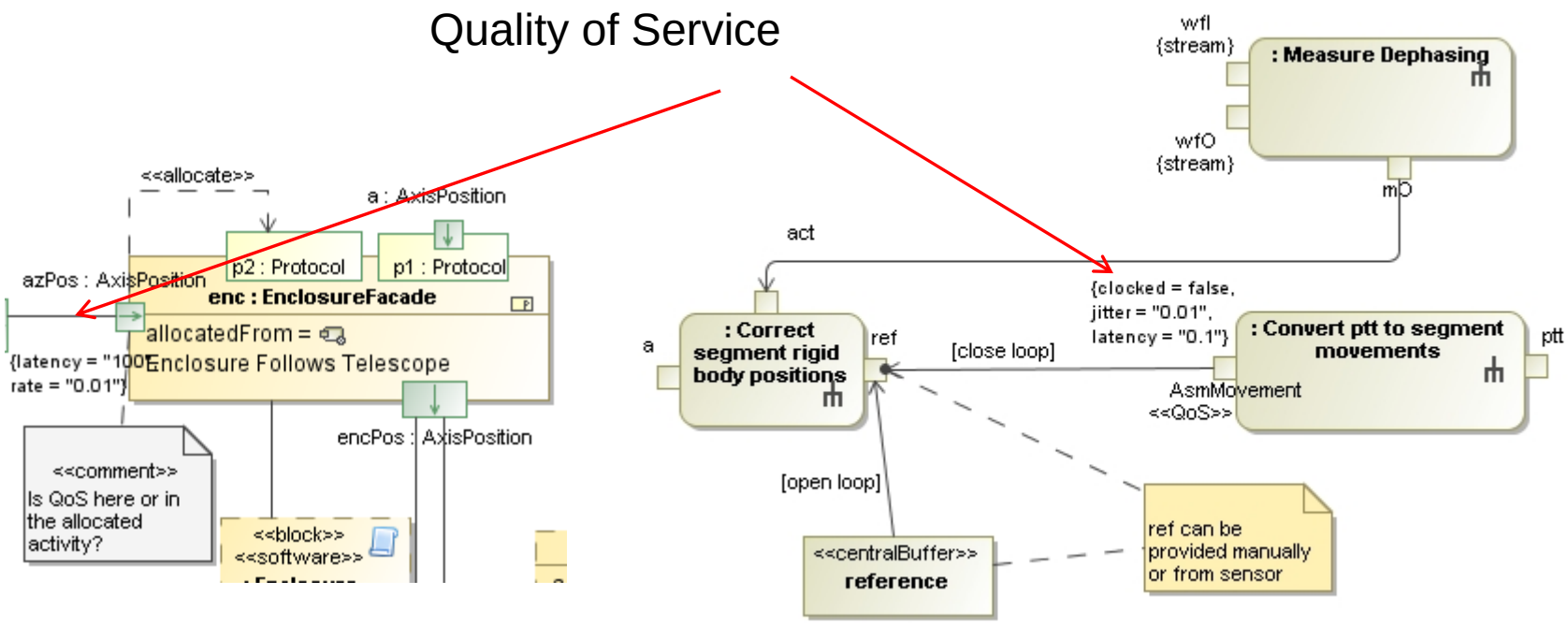
Cables in a part catalogue



Challenge: Re-use of blocks

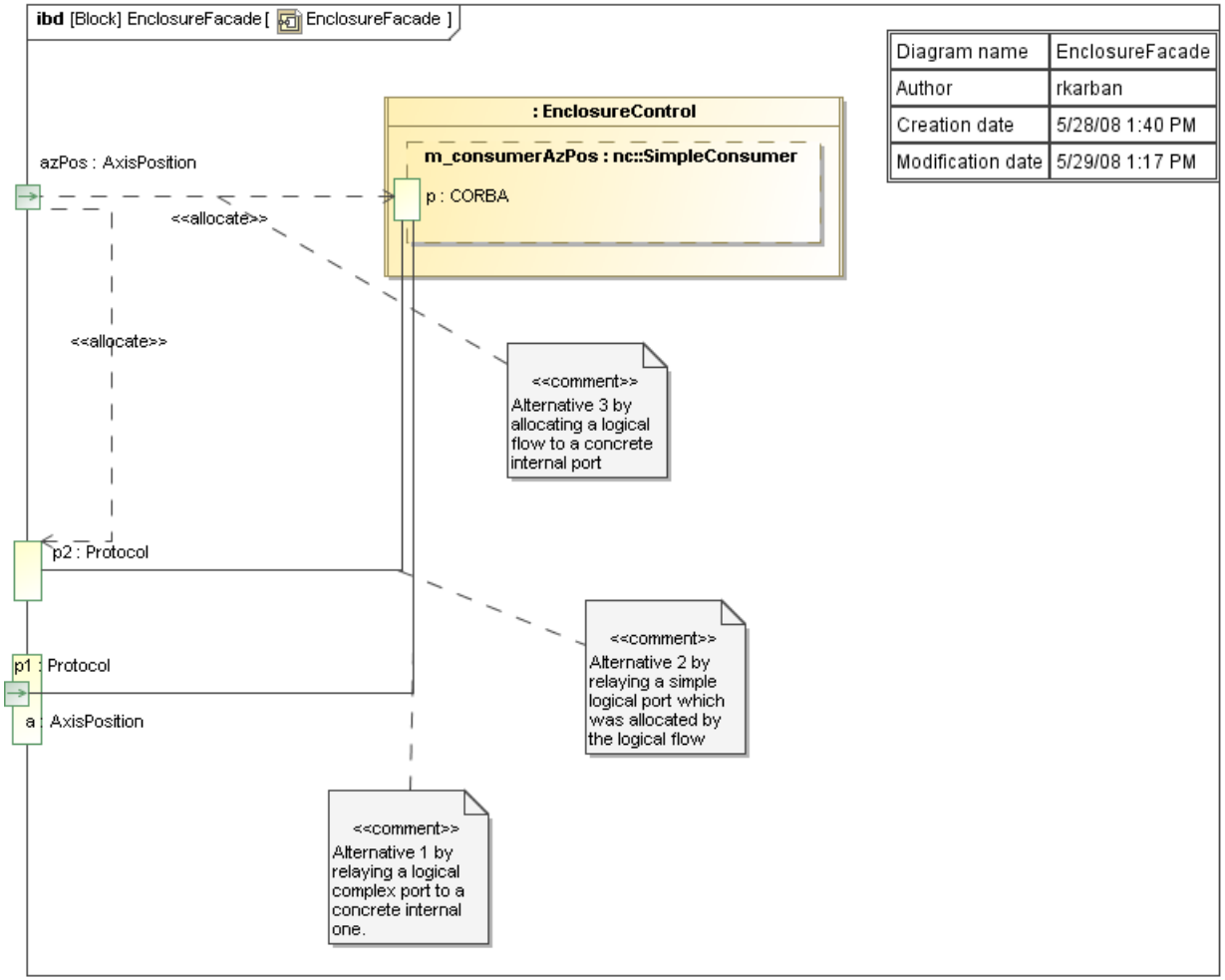


Challenge: QoS and Allocation



Challenge: Multi-layer allocation

Example for variations on allocation



Challenge: The Tool

- Formal implementation of standards
- Navigation through the model
- Printer size friendly diagrams
- Tables and matrices as input and output medium
- Support
- Documentation, Examples
- Performance

Configuration management approach

- SVN repository for native model files
- Partial packaging of (system) model segments into separate modules (=files)
  - ➔ Only partially successful, some arising consistency problems
- Trial of Teamwork Server
  - ➔Inflexible integration with SVN
  - ➔Not tested enough yet to give conclusion

➔Very tool dependent

Find out who changes what, where and when?

Tools and environment

- MagicDraw 15.1, SysML plugin 15.1
- Subversion, MD Team work server
- Windows PC
- Wiki for team communication
- E-Mail, phone and face to face meetings
- Limited time resources of all team members

Any other business

- MBSE practices used
  - 6 system views [Maier, Rechtin]
- Degree of execution
  - No such modeling tool capability
  - No need for risk reduction
- Model interchange capabilities
  - Not tried
- Training material
  - Navigable online model
  - List of Frequently Asked Questions

MBSE metrics

- Resource usage (1.12.2007 – 9.6.2008)
  - four persons
  - about 60h administration
  - about 150h modeling
- Model
  - about 13000 model elements
  - about 700 symbols
  - about 150 diagrams

MBSE findings, issues, and recommendations

- Modeling mentor
- Modeling recipes
- Modeling task force
- Guidelines for modeling - templates
- Guidelines for application of the tool
- Layout standards
- Model only as much as needed to understand the system

Plan forward

- Elaborate linking among different aspects
- Add more and more details in depth (system, subsystem, assembly, …)
- Logical vs. Physical hierarchies
- Multi-layer allocations, QoS, Reuse
- Transition SysML -> UML for software intensive systems

Acknowledgements

- Sandy Friedenthal
- Dr. Darren Kelly