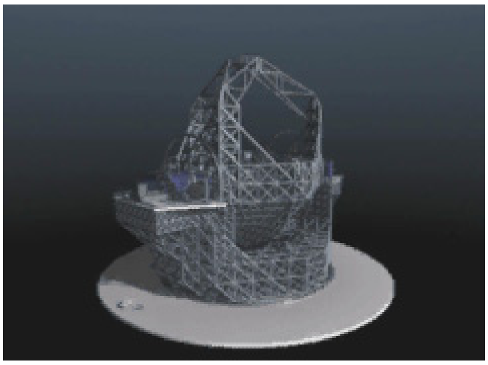
MBSE Challenge Team SE^2
OMG SysML for Telescope System Modeling




SysML for Telescope System Modeling

INCOSE MBSE Challenge Team SE^2
Robert Karban (ESO)
Tim Weilkiens (oose GmbH)
Andreas Peukert (TUM)
Rudolf Hauber (HOOD Group)

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Presented to the GfSE TdSE 2008

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This presentation describes the objectives of the INCOSE MBSE Challenge Team SE^2, the team and the structure current results of the OMG SysML for Telescope System Modeling.
A few word to the INCOSE MBSE Initiative, which is the background of the INCOSE MBSE Challenge Team SE^2.
Systems Engineering Vision 2020, Version 2.0 forecasts the state of practice for the field of systems engineering with near-term and far-term horizons of approximately five and 15 years, respectively. When matured, Systems Engineering Vision 2020 is intended to be the authoritative source of a shared vision for the global systems engineering community, and other interested stakeholders.
In leading the development of the Systems Engineering Vision, INCOSE is defining a 15 year view of the evolution of the systems engineering discipline. It addresses the future systems engineering environment, systems architecting, systems development, systems management systems engineering standards, and systems engineering education and research. In identifying the key capabilities required for the effective and competitive practice of systems engineering, this vision will help establish priorities for research in the systems domain.
Model-based systems engineering is the formalized application of modeling to support system requirements, design, analysis, verification and validation, beginning in the conceptual design phase and continuing throughout development and later life cycle phases. MBSE is expected to play an increasing role in the practice of systems engineering over the next several years.
INCOSE MBSE Challenge was initiated at INCOSE 2007 International Workshop (IW) to promote MBSE and is considered part of INCOSE MBSE Initiative.
Its purpose is to demonstrate solution to "Challenging" problems using MBSE , expect multiple MBSE Challenge Teams focused in different application domains, share insights, issues, and codification of MBSE practices, promote wider usage of MBSE, solve real world problems, attract resources to advance the MBSE practice and foster collaboration among and across domains.

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Agenda

- Introduction into SE^2 (Rudi)
- Introduction into APE project (Rudi)
- Modeling FAQ (Tim)
- Exemplary SysML diagrams (Tim)
- SysML Challenges (Tim)
- Outlook: Combine RM and SysML requirements modeling (Rudi)

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The presentation is organized as follows:
First an introduction into the INCOSE SE2 is given, then the ESO's APE project is presented.
Further some frequently asked modelling questions are considered and exemplary diagrams from the APE SysML model are shown
At the end some open SysML challenges are presented and an outlook to upcoming interfaces between modelling and other engineering disciplines is given to provide an inter-disciplinary engineering approach.

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OMG SysML for Telescope System Modeling

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)
  - Tim Weilkiens (oose GmbH)
  - Andreas Peukert (TU Munich)
  - Rudolf Hauber (HOOD Group)

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The SE^2 team is a collaboration between the European Southern Observatory (ESO) and the SysML working group of the German Chapter of INCOSE (GfSE).

ESO provides access to one of its high-tech projects funded by the European Union, the Active Phasing Experiment (APE).

The team members are geographically distributed with different technological background (Astronomy, Astronautics, Aerospace, Defence).

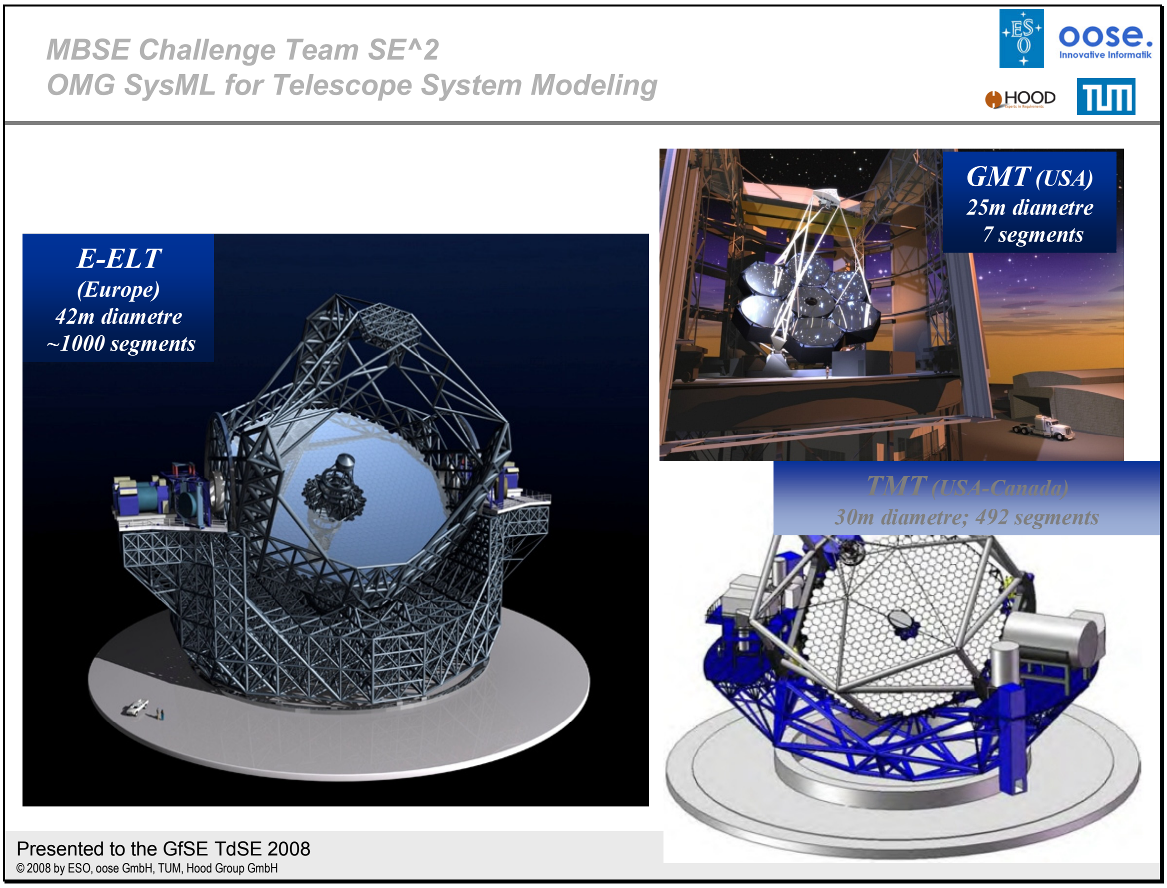
The core team consists of:

- Robert Karban (ESO) – team leader
- Andreas Peukert (TU Munich)
- Tim Weilkiens (oose GmbH)
- Rudolf Hauber (HOOD Group)

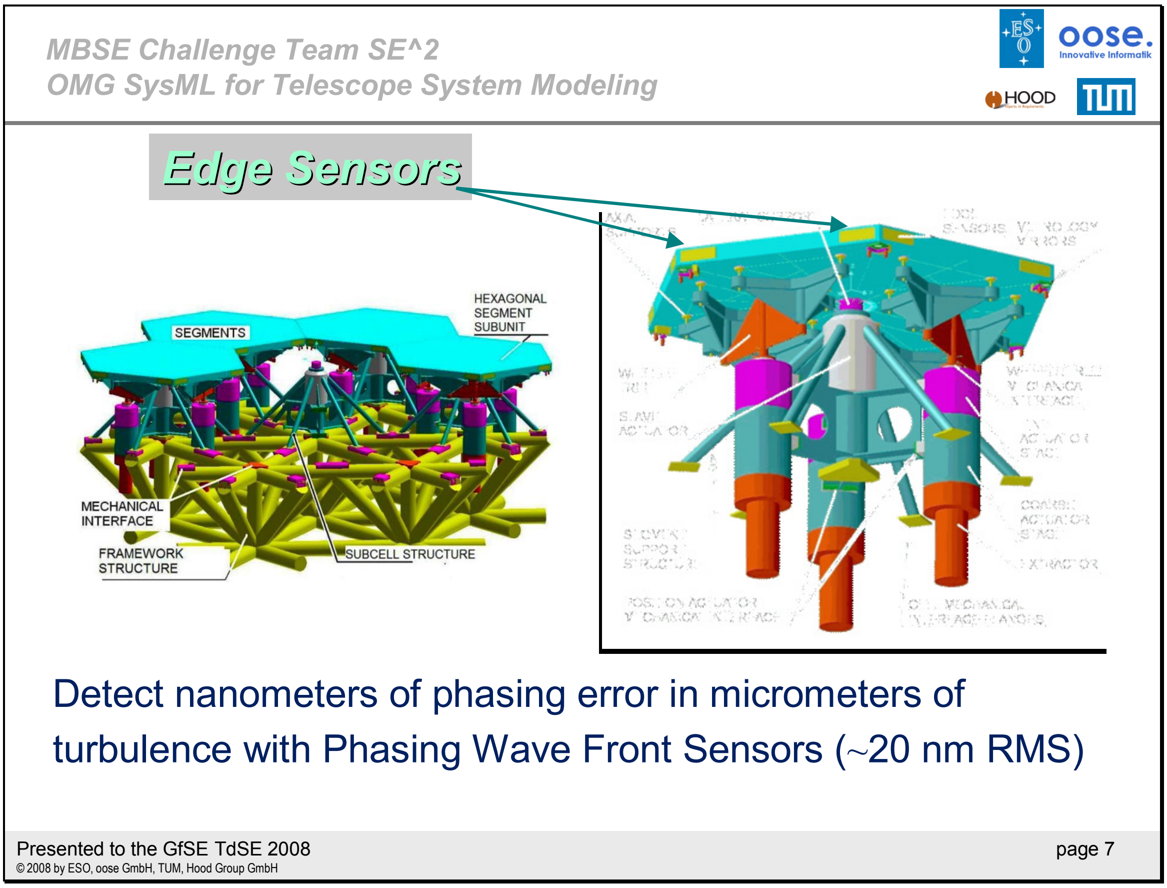
SE^2 goals

- Provide examples of
  - SysML
  - common modeling challenges
  - modeling approaches
- Build a comprehensive model which serves as the basis for providing different views to different engineering aspects (e.g. system, logical, mechanical, context) and subsequent activities of analysis and design alike.
- Demonstrate that SysML is an effective means to define common concepts (requirement types, interfaces, relationships, etc).
- Demonstrate that a SysML model enhances traceability between requirements, design and verification/validation.

The goals of the SE^2 MBSE Challenge Team are derived from the INCOSE MBSE Challenge goals to demonstrate solution to "Challenging" problems using MBSE based on SysML, expect multiple MBSE Challenge Teams focused in different application domains, share insights, issues, and codification of MBSE practices, promote wider usage of MBSE, solve real world problems, attract resources to advance the MBSE practice and foster collaboration among and across domains.



The goal of the next generation of telescopes is to collect much more light. Therefore very big mirrors are required which cannot be made any longer of one single piece.
The drawing shows a draft of the mechanical structure of the European Extremely Large Telescope (E-ELT) and its competitors, the GMT and TMT.
The E-ELT will be about 70m wide, where the primary mirror is 42m in diameter.
In order to have a 42 meter diameter mirror, the mirror is segmented in hexagonal pieces of about 1.5 diameter each. This results in 984 hexagonal segments. Due to different disturbances (vibrations, wind, gravity etc.) the segments must be actively controlled to get a continuous mirror surface with an accuracy of a few nanometres.



The wave front is distorted by various factors: one of them is a wrong positioning of the segments of the primary mirror which will result in a discontinuous surface.
This is compensated by the so-called phasing loop.

The main challenge is to correctly detect the positioning errors of the segments with specific sensors in order to bring the surface of the primary mirror close to the one of a monolithic mirror.

Edge Sensors are used to measure the position of the segments relative to each other at a closed loop of about 1Khz. Before the this loop can be closed the edge sensors must calibrated, which happens periodically. This calibration is carried out by so-called phasing sensors.

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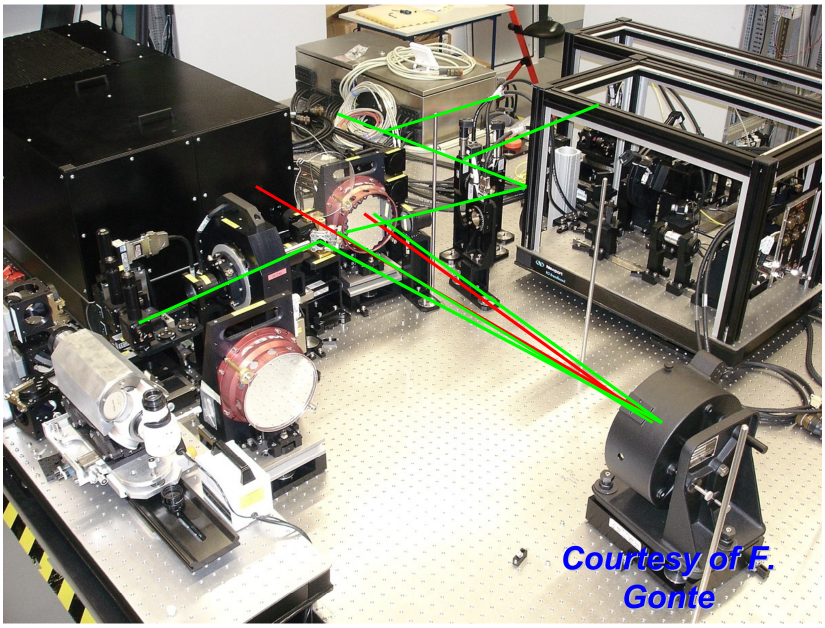

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The Active Phasing Experiment (APE) represents a technology evaluation breadboard for large telescopes. The essential purpose of the APE experiment is to explore, integrate, and validate active wave front control schemes and different phasing sensor technologies for a European Extremely Large Telescope (EELT). This includes the evaluation and comparison of the performance of different types of wave front sensors in the laboratory and on the sky on the one hand, and the integration of the control of a segmented aperture control into an already existing active system and driving both the active system and the control of the segments on the other hand. APE is close to completion and deployment in an operational environment. APE will be deployed in the lab, standalone, but also in an already existing telescope.

It contains an active segmented mirror (ASM) with 61 hexagonal elements of 1.2cm in diameter which can be controlled the same way as the future E-ELT primary mirror. The ASM can be controlled in piston (movement perpendicular to surface), tip and tilt (rotations about x/y, parallel to surface).

To evaluate the sensors capabilities a special metrology system is built (the Internal Metrology). Based on interferometric measurements,
it provides high accuracy (5 nanometers) to determine the exact position of the segments in piston, tip and tilt and simulate the edge sensors of the E-ELT.

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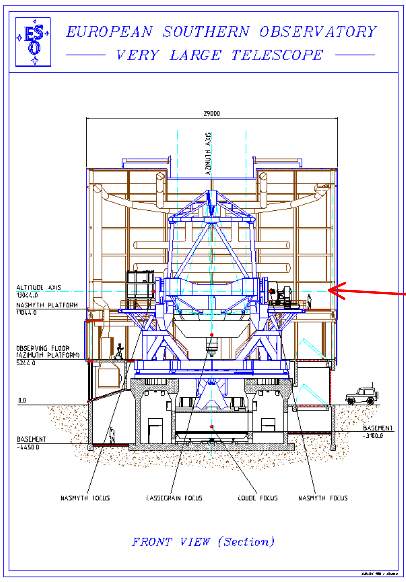

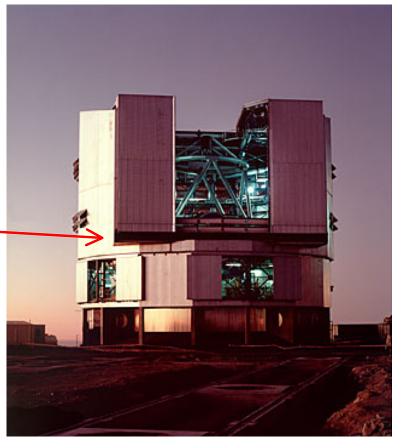

APE will be installed at the telescope in the Chile desert.

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To properly evaluate the sensors, APE will be installed on an existing telescope in order to work with real stars.
It will be installed on one of the VLT telescopes in Chile which belongs to the 8m class telescopes.
It is installed as a normal instrument on one of the so called Nasmyth platforms, indicated by the little man on the middle-right of the schematic drawing.
It has to comply with various mechanical, electrical, optical and software interface specifications for this installation.

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Deliverables:
Generic SysML modelling FAQ: Excerpt 1/2

- General modeling guidelines
  - How should I name model elements?
  - What rules should I follow when creating diagrams
  - How should I document the model?
  - How do I use different types of annotations in the model?
  - How should I structure the model by using packages?
  - How do I include external references?
- Guidelines for necessary system models and aspects
  - What system views should my (structural) model contain?
  - How many levels of abstraction do I need?
- Guidelines for modeling the system requirements
  - How should I use dependency matrices?
  - How do I model relationships between requirement and design element?

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The project is modeled in different aspects, each serving a particular purpose: Requirements, Context, Structure, Behavior, Data, Verification and Performance.
This very same structure is recursively used for all its major sub systems which allows rather self-contained packages covering all aspects.
This is in particular important for sub-contracting complete sub systems and organize the system development.
The Context defines the scope of the system and its interfaces with its environment.
Requirements for each sub-system are derived from system requirements, which refine user requirements which in turn are traced to Objectives.
The Structure is organized according to the product tree.

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Deliverables:
Generic SysML modelling FAQ: Excerpt 2/2

- Guidelines for modeling the system structure
  - How do I distinguish a sub structure and an assembly?
  - How do I model different contexts?
  - Where do I put systems which are part of the project and needed in different contexts but nor part of the system itself?
  - When should I use block, data or value types?
  - How do I model re-usable parts, like a catalogue of building blocks?
  - Where do I put (new) domain specific model elements, like stereotypes?
  - How do I model domain specific values and types?
  - How do I model design variants?
  - How do I define system hierarchies?

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As interface are the basic element of an architecture it is very important to have a reduced picture of an interface (not only a CAD drawing).
A significant effort was spent to define different variants, depending on the modeling goal.
In general there are only 2 abstraction levels – functional and structure and allocating function to structure.
No explicit logical structure is needed – the functional view is sufficient.
The same applies for control system but there exists an additional deployment level for allocation of SW components to HW components.

For the Performance model only a concept for modeling the optical error budget is ready. It is to be completed.

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Deliverables:
SysML model for the APE project

- 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

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The deliverables of the SE^2 team is a SysML model for the APE project, which consists of three major model parts:
The actual system model APE (with all mentioned system aspects), a catalogue model with standard parts, library of block prototypes and a modelling profile with additional stereotypes.
Its main characteristics are a scalable model structure and organisation, which includes model annotations, external references and various examples of ports and flows to model interfaces.
It has three abstraction levels: the functional architecture, the structural architecture and the deployment.
Preliminary results are available at mbse.sysmod.de

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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

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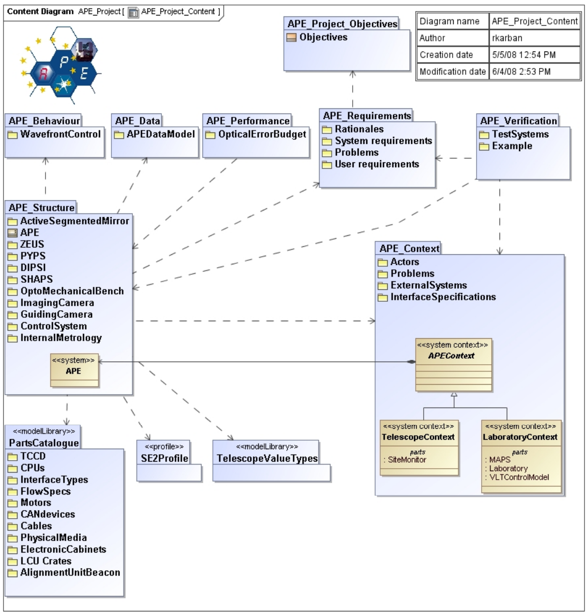
APE project : Overview



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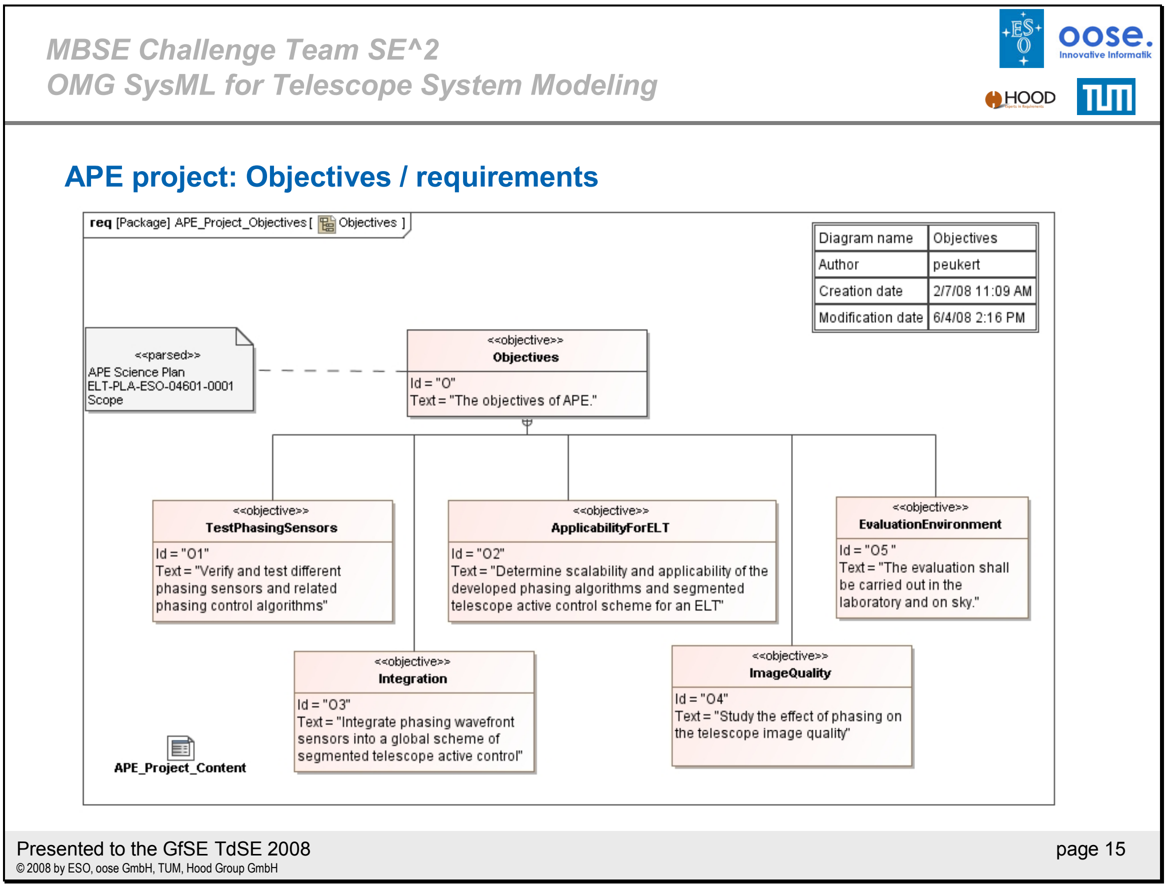
The Project Content diagram shows all different aspects and models needed to describe a system. APE, as any complex system, has a large number of functional, performance, physical and interface requirements which have to be satisfied. This implies the need for a professional requirements engineering and management during the project. This is the first application of SysML during the development.

APE has about 50 high-level system requirements. The control system has also about 50 requirements, complemented by 150 Use Cases.

APE consists of various elements, like wheels, translation stages, lenses, detectors, (segmented) mirrors, light sources, an interferometer, sensors and actuators (19 small axes, 10 TCCDs, 11 other devices, 183 actuators for segmented mirror). The control system alone consists of 12 computing nodes. These elements offer all kinds of optical, mechanical, electronic and software interfaces, both system internal and external to other systems. Their management alone is very challenging for the systems engineering team. Besides these challenges, which apply for many complex systems, APE has some other aspects:

The most noticeable challenge of APE is the highly demanding optical layout, which is a unique challenge for every optical system. The highly sensitive system requires a consistent coordinate system of the various parts to ensure a correct optical path. Apart from this it also challenges the control, since there are several open and closed loop systems required. A significant amount of data is produced by image processing data flows. Since APE will be deployed in the lab and in an already existing telescope, slightly different functional aspects are active depending on the deployment mode. Therefore different interfaces to existing systems are needed.



The major challenge for SysML is to add value for systems engineering of interdisciplinary projects. For the demonstration of the feasibility of using SysML during the systems engineering process of real-world complex systems, such a system shall be modeled. APE, a project of ESO, is chosen as a case study which fulfills these aspects.

The main objectives of APE are shown in a requirements diagram.

Why are we modeling requirements and not only use a requirements management tool as DOORS? Benefit of modeling requirements are:

- One central repository for system engineering.
- Visualization of key requirements
- Clustering of coherent requirements (use cases)
- Visualization key requirements impact on design and test

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APE project : Traceability of requirements

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 […
APE_Project_Objectives [APE]	1		2	1	1	1	1	1	1	2	1	1	1	
Objectives [APE::APE_Proj…	↙													
Objectives [APE::APE_Proj…			2	1	1	1	1	1	1	2	1	1	1	
ApplicabilityForELT [APE…							↙	↙		↙			↙	
EvaluationEnvironment […			↙	↙										
ImageQuality [APE::APE…			↙							↙				
Integration [APE::APE_…											↙	↙		
TestPhasingSensors [AP…					↙	↙			↙					

	CalbrationTimeOf…	CalibrationTimeO…	MaximumTelesco…	MeasurementTim…	Report [APE::AP…	ResidualPSF [APE…	ScallopingEffect […	SegmentationErr…	SensorPlatform […	SimultanousContr…	TestRequirement…	ClosedLoopMeas…	OpenLoopMeasur…	UT of the VLT [AP…	VerificationOnSky…
APE_Project_Objectives [APE]	1	1	1	1	1	1	1	1	1	1		1	1		2
Objectives [APE::APE_Proj…															
Objectives [APE::APE_Proj…	1	1	1	1	1	1	1	1	1	1		1	1		2
ApplicabilityForELT [APE…	↙	↙	↙	↙	↙										
EvaluationEnvironment […															↙
ImageQuality [APE::APE…						↙									↙
Integration [APE::APE_…										↙					
TestPhasingSensors [AP…							↙	↙	↙			↙	↙		

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Completeness of traceability can be checked by automatically creating dependency matrices.

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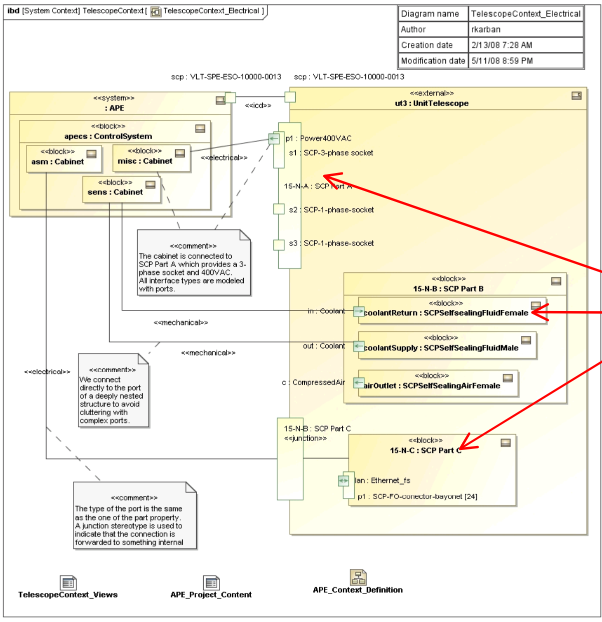
APE system model: System context



3 modeling approaches for interfaces
➔ treated later in challenges

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The System context is modeled using IBDs. Our main focus is on system interfaces.
Three different possibilities are shown to model an interface

- Combination of mechanical and flow interface at block level (Model physical and logical properties at border of block without opening it.)
- Mechanical and flow interface at part level
- Mechanical and flow interface at block and part level.
- Abstract interface representing and ICD (using standard ports).

Problem is ensuring consistency between ICD document and the model which is used to create the ICD.

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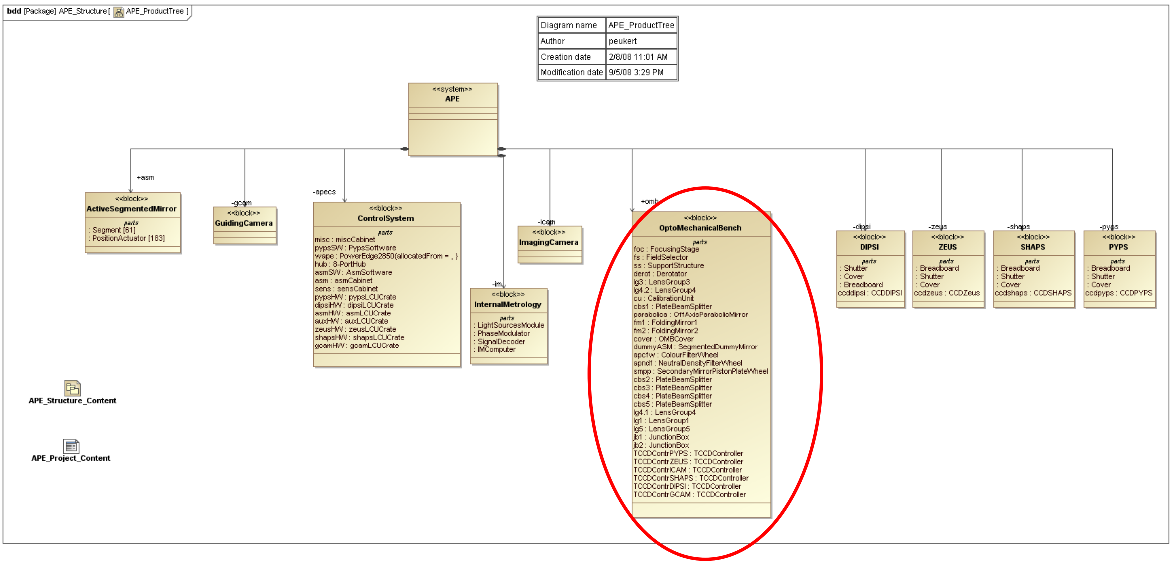
APE system model: Structure: Hierarchical breakdown

"Product tree" of APE



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Complex models tend to become very quick confusing.
A good model structure is the key to keep the model understandable.
Our structure is based on product tree. The product tree is defined by a BDD.

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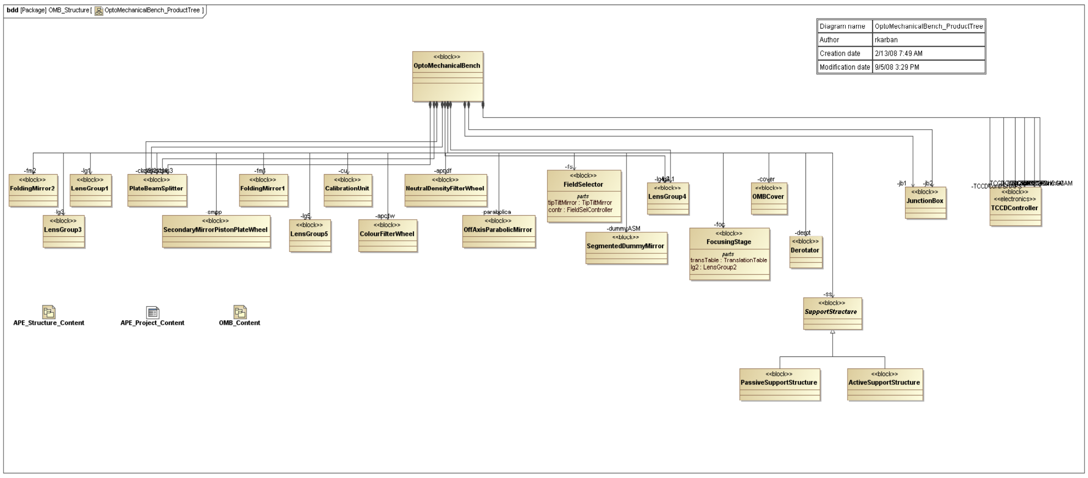
APE system model: Structure: Hierarchical breakdown

"Product tree" of Opto-Mechanical Bench



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The product tree has several levels, going from the highest level into more and more details, using decomposition of its elements.

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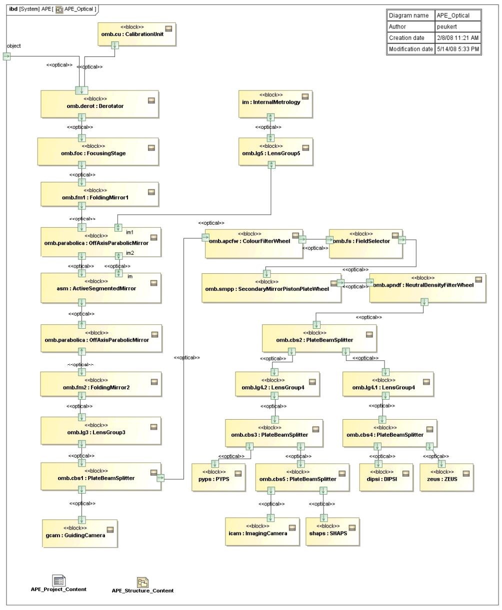
APE system model: Structure: Internal structure



"Optical view" of APE

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A model is much more than just a couple of diagrams. A model consists of multiple views showing different aspects of the system that are interconnected.
The same components can be connected in different views in different ways. This diagrams shows the optical layout in an abstract manner.

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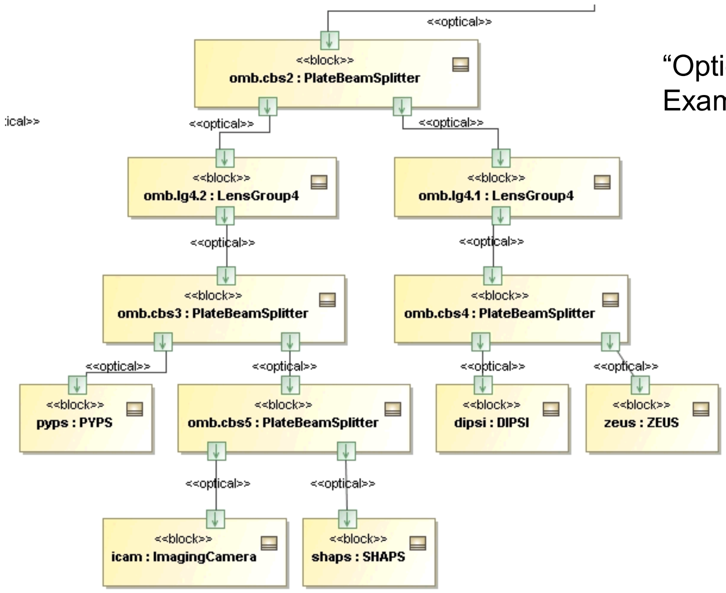
APE system model: Structure: Internal structure



"Optical view" of APE:
Example for using nested parts

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This diagrams zooms into the optical view.

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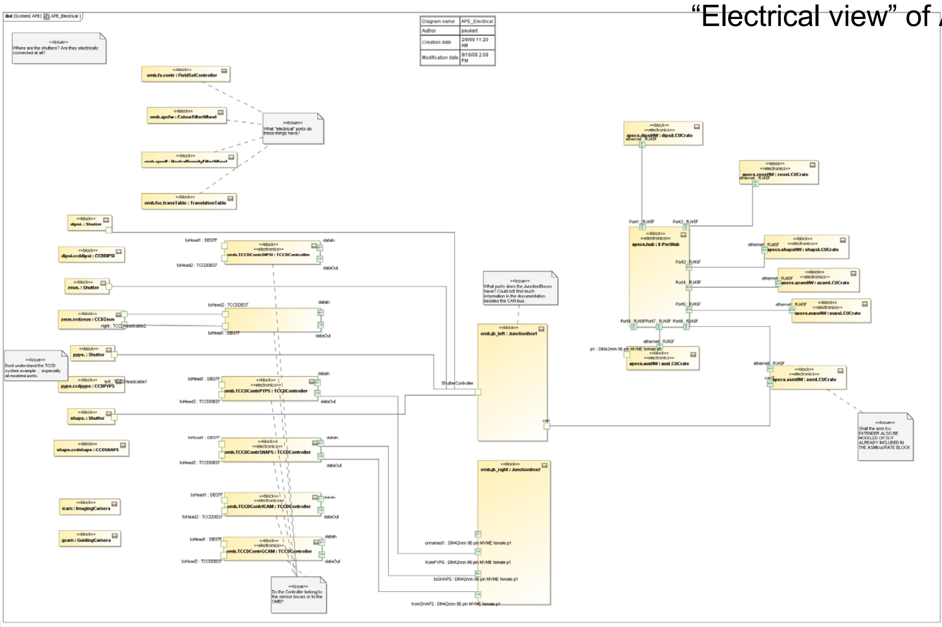
APE system model: Structure: Internal structure

"Electrical view" of APE



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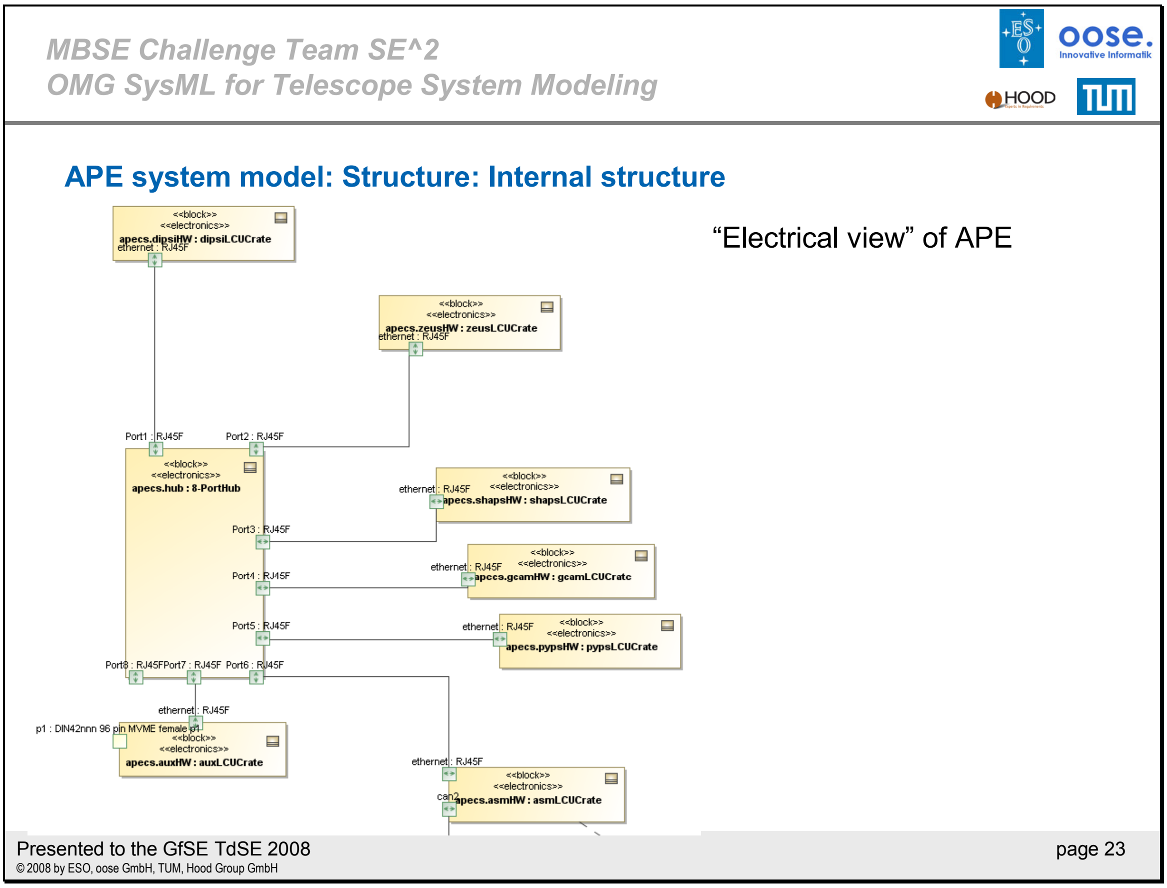
This diagrams shows a different view onto the same system: the electrical layout in an abstract manner.



This diagrams zooms into the electrical view.

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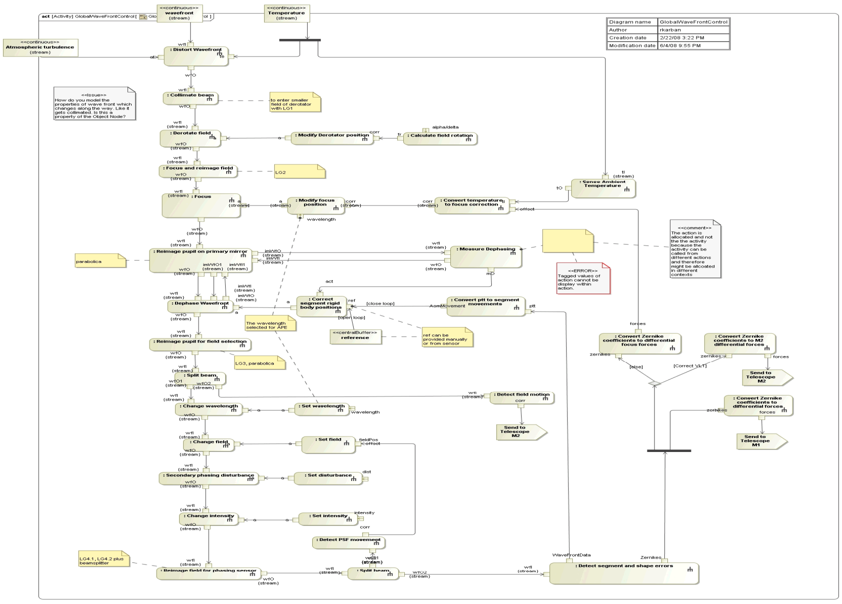
APE system model: Behavior



Activity "Control Wavefront" of APE

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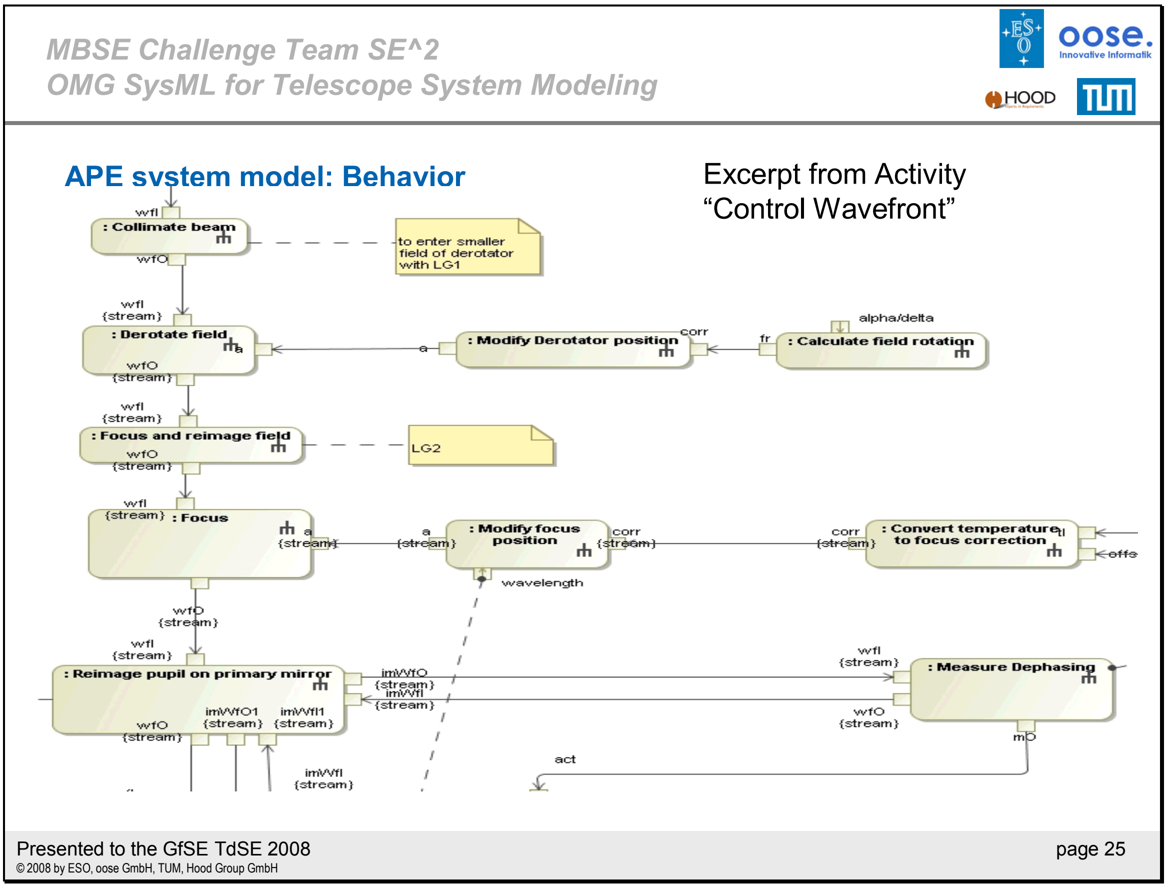
The model shows at the same time the physical effect of a system (like distortion of wave front) as well as sensing, actuating actions and control flows.



The model shows at the same time the physical effect of a system (like distortion of wave front) as well as sensing, actuating actions and control flows.

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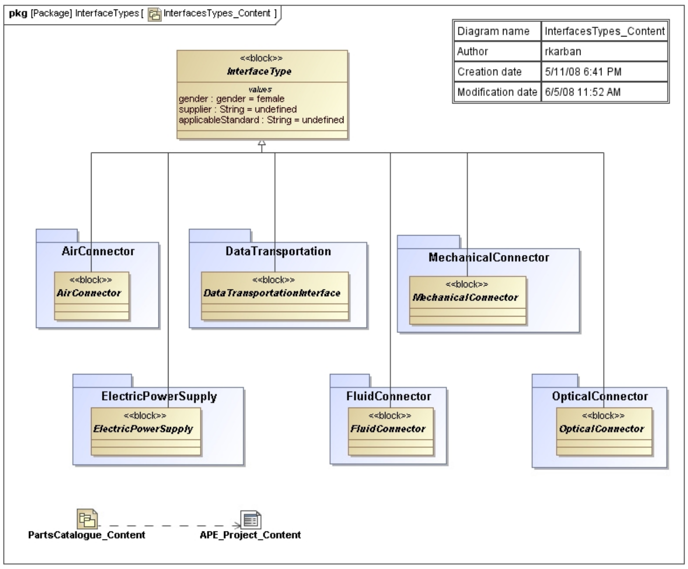
Catalogue model: Abstract types

Example for catalogue:



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Abstract types are used as place holder for specific building blocks. They are classified in different packages.

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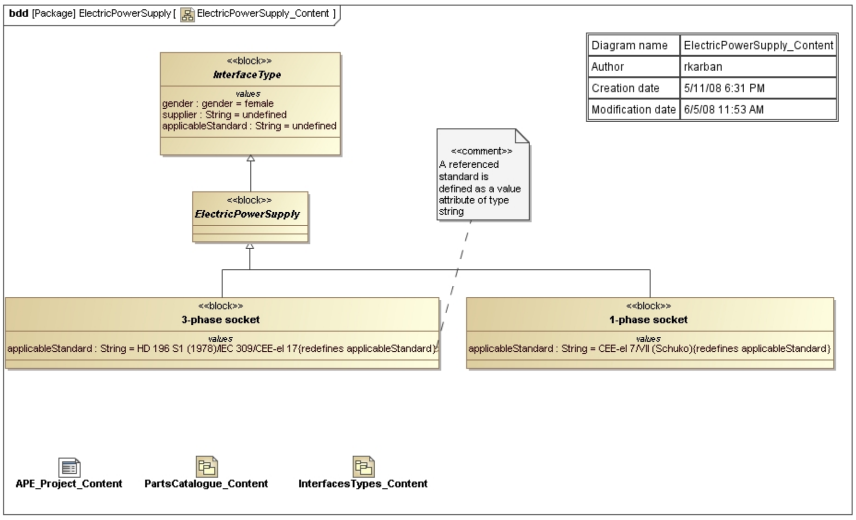
Catalogue model: Concrete types

Example for catalogue: Power Supply Interfaces



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Catalogues can be easily extended by using inheritance. Furthermore the preliminary design of a system can work with an abstract type (when the detailed requirements are yet unknown) and decide later which specific type to use for the implementation.

Standards are defined by value properties which can be redefined in sub classes.

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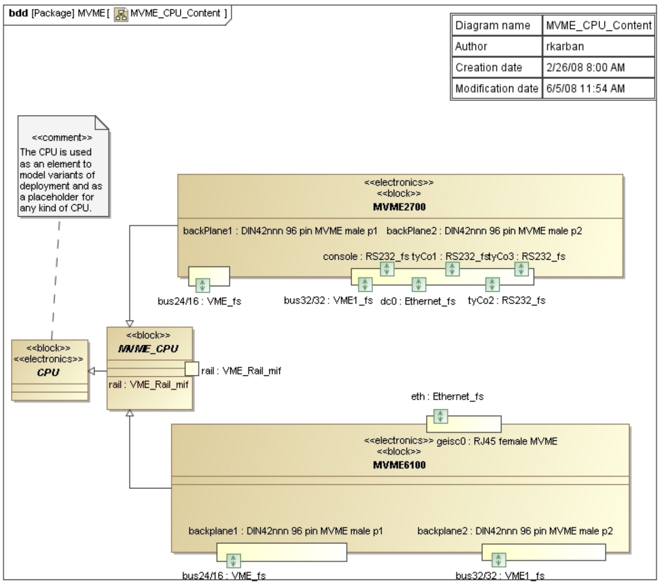
Catalogue model: Type usage

Example for catalogue:
CPU types and different flow port assignments



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Parts can be used differently in different contexts (different items flow over the same type of connector). Here a 96 pin connector has a different assignment.
A generic connector gets a different context specific assignment by inheritance. For each specific assignment a separate specialization is needed.

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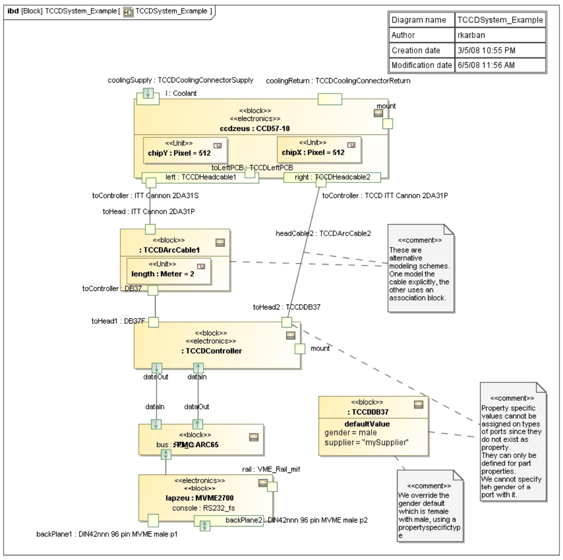
Catalogue model: Assembling the pieces

Example for a complex catalogue part, a TCCD



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Cables are modeled using blocks or association blocks.

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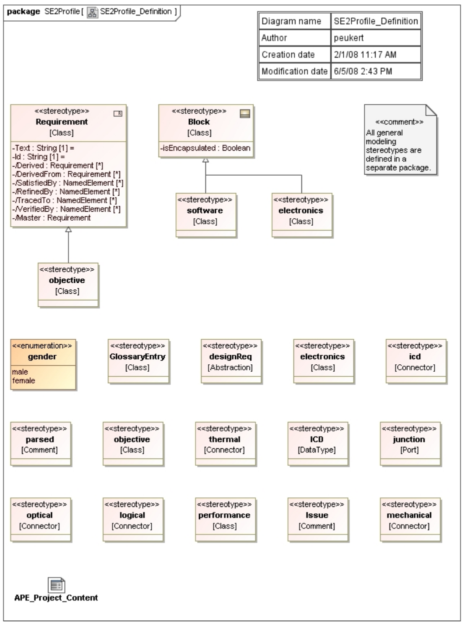
Modelling profile

Example from SE^2 profile:



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The SE^2 profile extends the SysML by adding stereotypes for different connectors (optical, mechanical), specific block types (Software, Electronics).

We see SysML as a integration platform for many SE tasks and tools.
For example for standardized interfaces have to be established to tools like:

- Matlab/Simluink
- CAD
- ILS planning and so on

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SysML Challenges

The MBSE Challenge Team SE^2 found out several challenges for SysML. That wasn‘t a big surprise, because

- OMG SysML 1.0 has known lacks of elements.
- the APE project is challenging.

The outcomes of the SE^2 team are directly reported to the OMG SysML working group (RTF):

- SE^2 gets support from Sanford Friedenthal (ex-chair of SysML Partners)
- SE^2 gets support from Dr. Darren Kelly (member of SysML RTF)
- SE^2 member Tim Weilkiens is co-author of SysML specification and member of SysML RTF.

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The APE modelling project is a great challenge for SysML and SysML modelling tools. The project includes many different aspects of the systems engineering discipline.

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SysML Challenges

- Combining different aspects with nested ports
- Variant modeling
- Different types of interfaces like mechanical, electrical, logical, interface based on a standard document
- Connection of nested blocks
- SysML modeling tool

- Reuse of (association) blocks, Property specific types
- Defining QoS
- Multi-layer abstraction (like ISO OSI model)
- Mapping activities to blocks
- and more.

Note: *Order has no meaning, e.g. priority*

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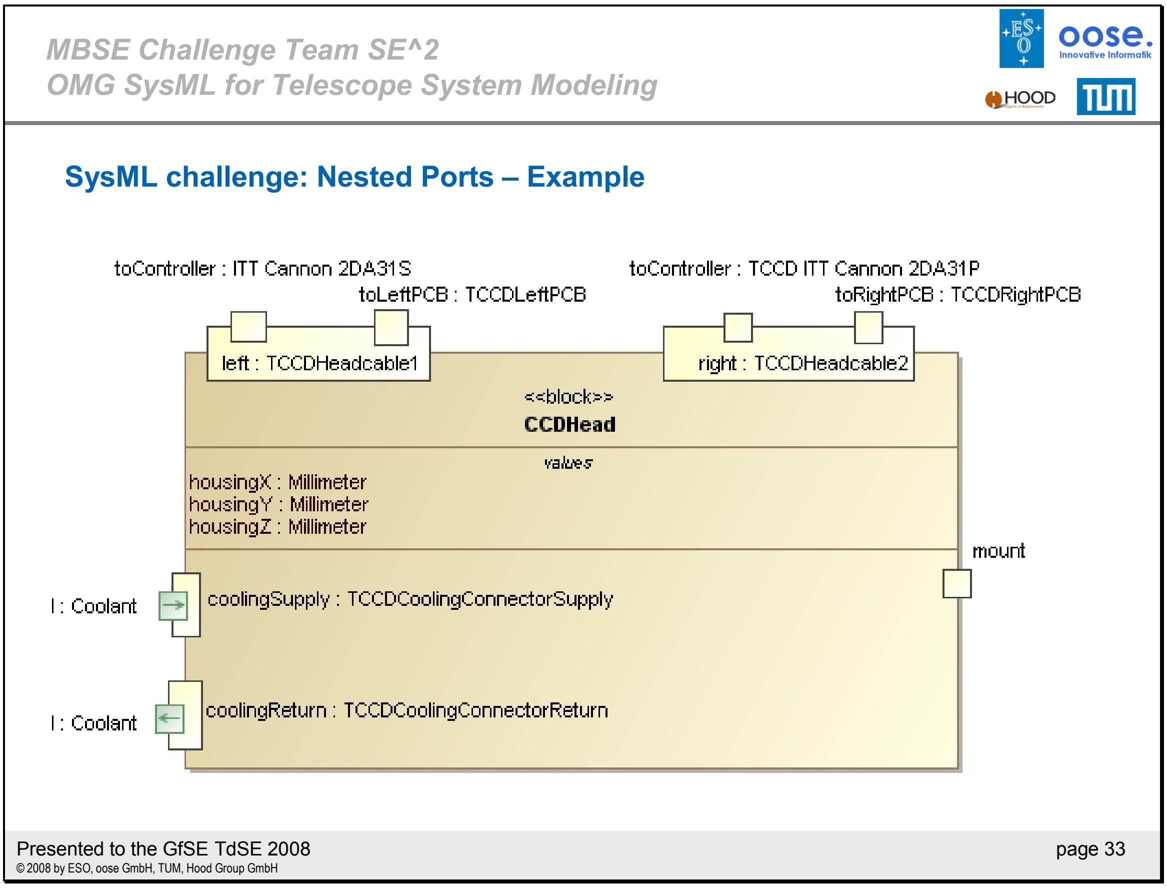
The challenges from the upper part of the list are shown in more detail on the following slides.



By using nested ports, the cable is a standard port with standard sub ports which represent both ends of the cable. This is particular useful when a cable is permanently soldered to a chip, like here to a CCD head PCB.

Nested ports have proven to be very useful if different interface properties shall be shown at the same time:

- Mechanical interface and protocol (e.g. RJ45 and Ethernet)
- Different Assignments of Pins on a plug (96 VME pin has vendor specific pin assignments, like serial or Ethernet)
- Modeling interfaces and logical channels
- Bundling port types, like grouping all electrical flows into one port.
- Model cables using nested ports.

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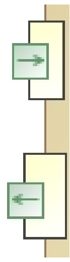
SysML challenge: Nested Ports – Characteristics



Notion

- MBSE Challenge Team SE^2 and other projects found out that it is a necessary feature.
- Standard SysML modeling hardly shows the relationship of the ports.

How to

- The type of the port itself owns ports.

SysML status

- Nested ports are not officially supported by OMG SysML 1.1.
- The syntax is valid, the semantic is undefined.
- Issue for SysML 1.1, but deferred for future versions.

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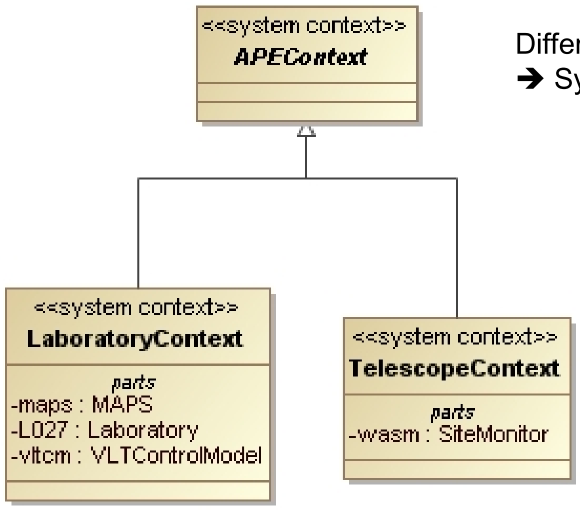
SysML challenge: Variant modeling – Example



Different contexts imply different design
➔ System variants

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APE has two variants, represented by different contexts (Lab and Telescope). Depending on the context different parts must be used which are deeply nested in the product tree (e.g. Support structure in the lab and support structure on the telescope). The problem is how to relate this information, i.e. how do you model that those parts are depending on the context? Tags are used to associate parts with variants.

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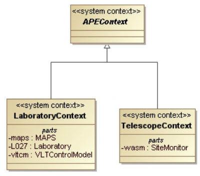
SysML challenge: Variant modeling – Characteristics



Notion

- It‘s an objective of SysML to support evaluation of different system designs.
- Variants are common in system modeling.

How to

- Generalization
- Profile with stereotypes for variants (e.g. SYSMOD, FODA)
    - Tags for identifying parts and associated variants

SysML status

- Variant modeling is not officially supported by OMG SysML 1.1.
- Intentionally left out in OMG SysML.
- Planned feature for OMG SysML 2.0.

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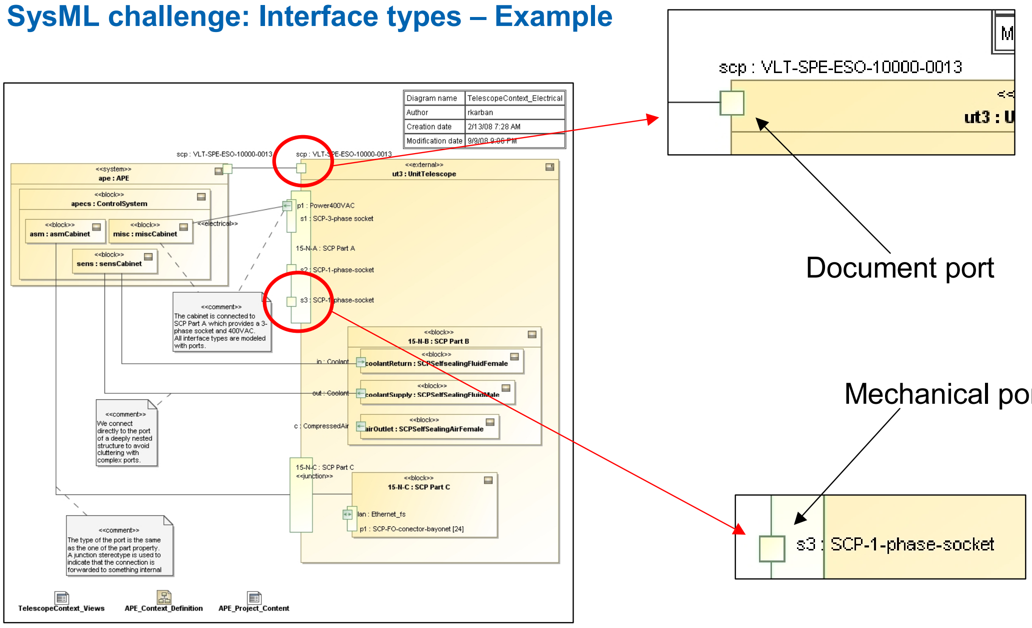
SysML challenge: Interface types – Example



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Different possibilities are shown to model an interface

- Combination of mechanical and flow interface at block level (Model physical and logical properties at border of block without opening it.)
- Mechanical and flow interface at block and part level.
- “Abstract” interface representing and ICD (using standard ports).

SysML challenge: Interface types – Characteristics

Notion

- SysML doesn't differenciate intrinsic between different interface types like logical, mechanical, ...
- It is important to differentiate between types, e.g. for views.

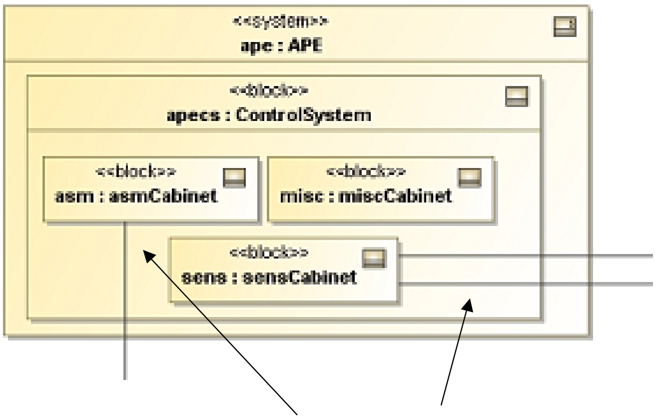
How to

- Profile with stereotypes for interfaces types (e.g. SYSMOD)
- Special port types

SysML status

- There are no plans to support discipline specific interfaces types. That would be contradictory to the unified approach of SysML. It's a task for the stereotypes mechanism.

SysML challenge: Connection of nested blocks – Example (1/2)



Nested blocks are connected directly with blocks outside.
<u>Problem:</u> Hiding internal blocks hides also the relationships.

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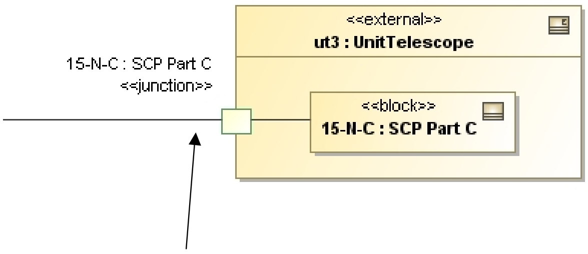
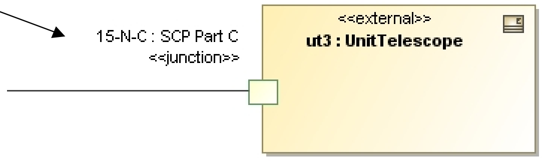
SysML challenge: Connection of nested blocks – Example (2/2)



Use a junction port as a proxy for the internal block.
Hiding nested blocks doesn't effect the relationships.



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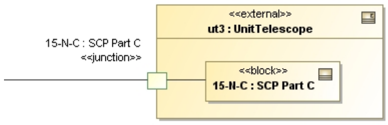
SysML challenge: Connection of nested blocks – Characteristics



Notion

- It must be possible to hide nested blocks without loosing the view on their relationships to external blocks.

How to

- Use ports with stereotype as a proxy for a nested block.

SysML status

- The probelm is recognized by the SysML working group.
- Issue for SysML 1.1, but deferred for future versions.

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Challenge: The SysML Modeling Tool

- Formal implementation of standards
- Navigation through the model
- Printer-size friendly diagrams
- Documentation, Examples
- Performance
- Tool interchange

- Support from vendor (licenses for SE^2)
- Provide feedback to vendor

More formality avoids wrong application of SysML. Less formality would kill unambiguous communication of information.

Navigation:
There is an open issue about navigation to the different views of a block (mechanical, optical, ...). Each view is represented by an IBD.
Different views exist for the same block i.e. IBDs for optical, mechanical, etc.

What’s the best way to see that a block has different views and to navigate there?

Support from vendor
- license
- quick response to support requests
- valuable advice in applying the tool correctly when modeling systems

Feedback to vendor
- models
- bug reports and proposals for improvements

MBSE findings, issues, and recommendations

- Modeling aims
- Modeling mentor
- Modeling recipes
- Modeling task force
- Guidelines for modeling (templates, checklists, …)
- Guidelines for application of the tool
- Layout standards
- Model only as much as needed.

- First of all, the aims of system modelling must be defined.
- A modeling mentor is indispensible
- Define modeling recipe for particular problem
- Task force creates a first base line
- Establish modeling guidelines (FAQ), otherwise you get only a set of inconsistent diagrams and enforce them by templates built-into the tool.
- Setup guidelines for application of the tool
- Layout standards: Integration in documents and visualization on screen becomes difficult without layout standards, like a maximum diagram size (e.g. A4).
- Model only as much as needed. Modeling is not an end in itself!

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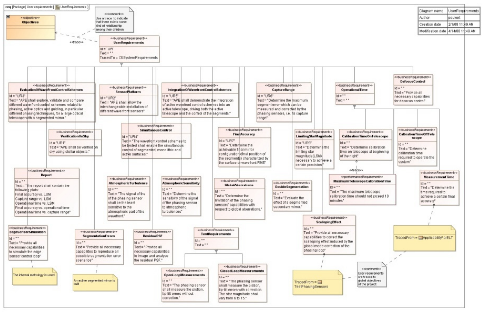
Plan forward: SysML Requirements Modeling and RM

- Current situation
  - SysML offers requirements modeling capabilities: <<Requirement>>, <<refine>>, <<derive>>, <<satisfy>>,….
  - APE guideline for requirements modeling
  - Usage: Important requirements and relationships can be visualized
- Not practical for RM of large projects
  - No support for project specific RM information model
  - No support for traceability analysis
- Combine best of RM and system modeling
  - Well-tried RM still necessary (FURPS)
  - No controversy about "right" approach
  - A *standardized* concept is needed



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The current SysML support for requirements modeling is not sufficient for large projects. Combining „traditional" RM and SysML in a standardized way offers new benefits and avoid „method-wars".

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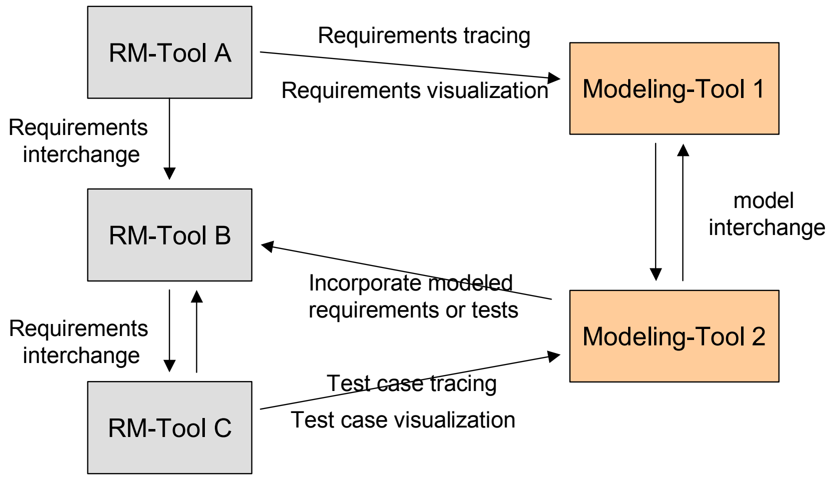
RM-Tool – SysML Tool Interchange vision

- Connecting Requirement Interchange Format (RIF) and SysML offers improved SE benefits



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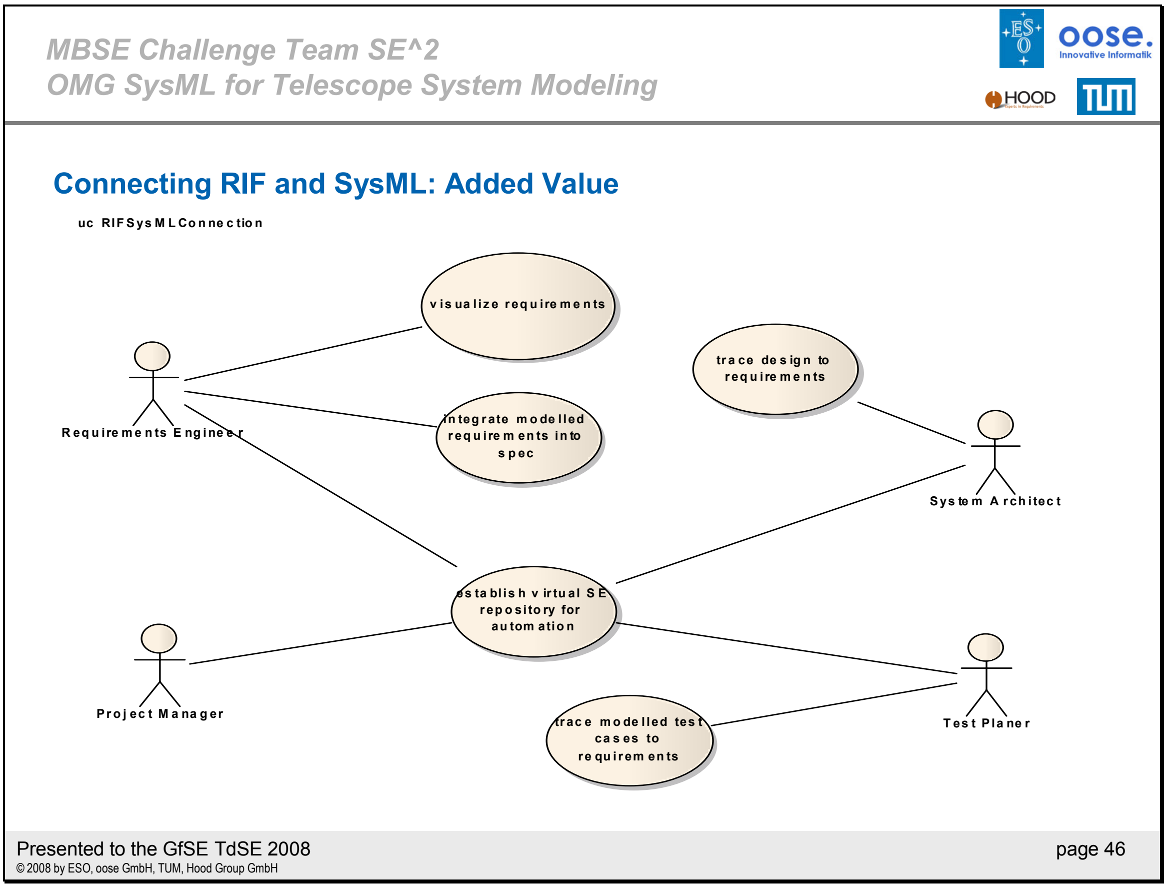
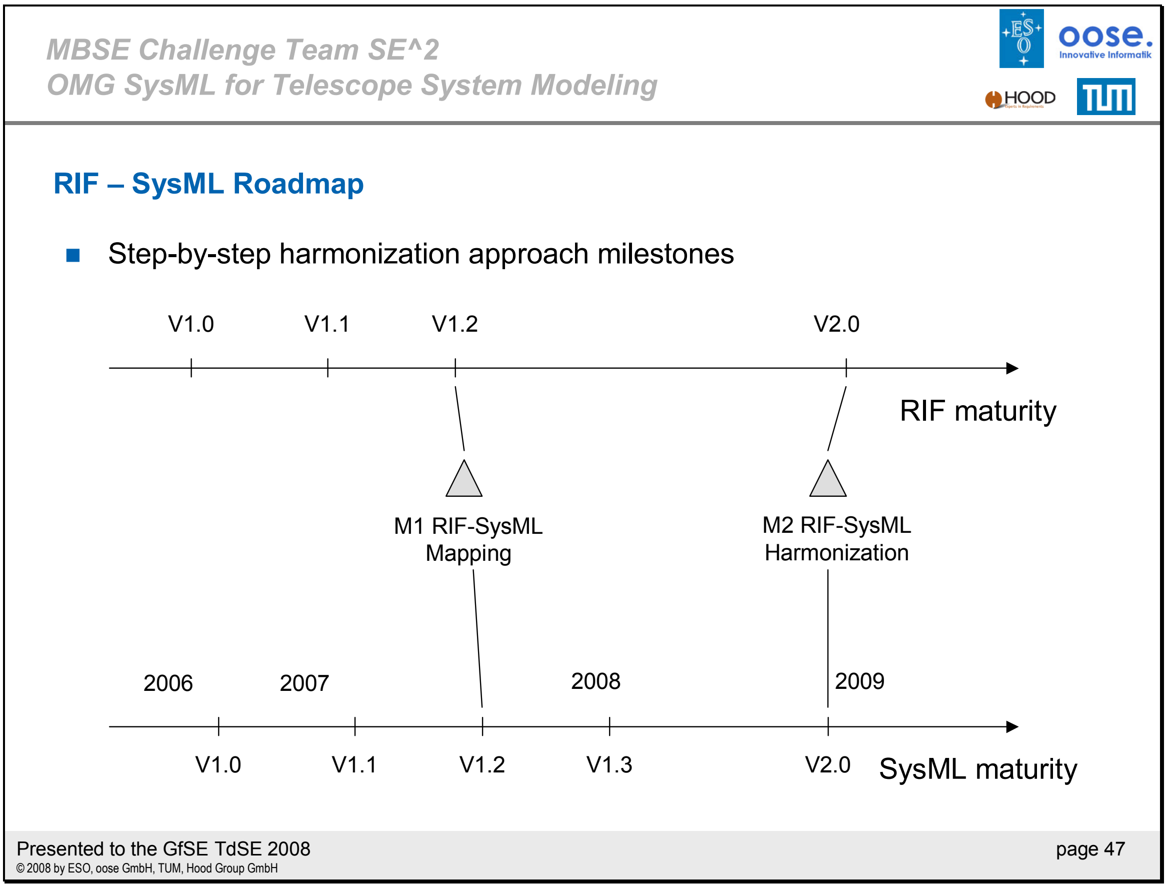
Connecting Requirement Interchange Format (RIF) and SysML offers new SE benefits of requirements tracing and visualization, test case tracing and visualization, incorporating modeled requirements or tests in RM.



This a same of the new system engineering use cases that benefits from connecting RIF and SysML.



This is the idea of a first road map to align RIF and SysML from the Utrecht and the Ottawa INCOSE meeting with Sandy Friedenthal.

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SysML profile for RIF

- Proposal of a SysML profile to formalize the mapping
  - <<Requirement>> specializes the SysML::Requirements::Requirement
  - <<RequirementType>> is a new stereotype for Class
  - <<ReqRelation>> is a new stereotype for Association
  - <<ReqGroup>> is a new stereotype for Package
  - <<ReqHierarchy>> specializes the SysML::Requirement containment relationship
  - <<RelationGroup>> is a new stereotype for Package
  - <<metamodel>> is a new stereotype for Dependency
- More details are available in the “Connecting Requirements Interchange Format (RIF) and SysML requirements modelling” paper

  ➔ Rudolf.Hauber@HOOD-Group.com

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This is a first draft of a SysML profile for RIF.