SysML for Telescope System Modeling

by the

INCOSE MBSE Challenge Team SE^2

Agenda

- What is SE^2
- What is ESO?
- What is the Challenge project about?
- What have we achieved?
- Problems already addressed
- Open Issues
- Applying Practices and Guidelines
- What is next?
- Live Demo of the Model

About SE^2

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

ESO

Non-profit Intergovernmental European Organisation for Astronomical Research in the Southern Hemisphere

http://www.eso.org

Headquarters in Munich, Germany, 3 Observatories in Chile

Mission statement

Build and operate world class ground based astronomical facilities

ESO major projects

Very Large Telescope (VLT)

Started 1988, in operation since 1999

Atacama Large Millimeter Array (ALMA)

Europe-US-Japan

Started 1998, installation starting now

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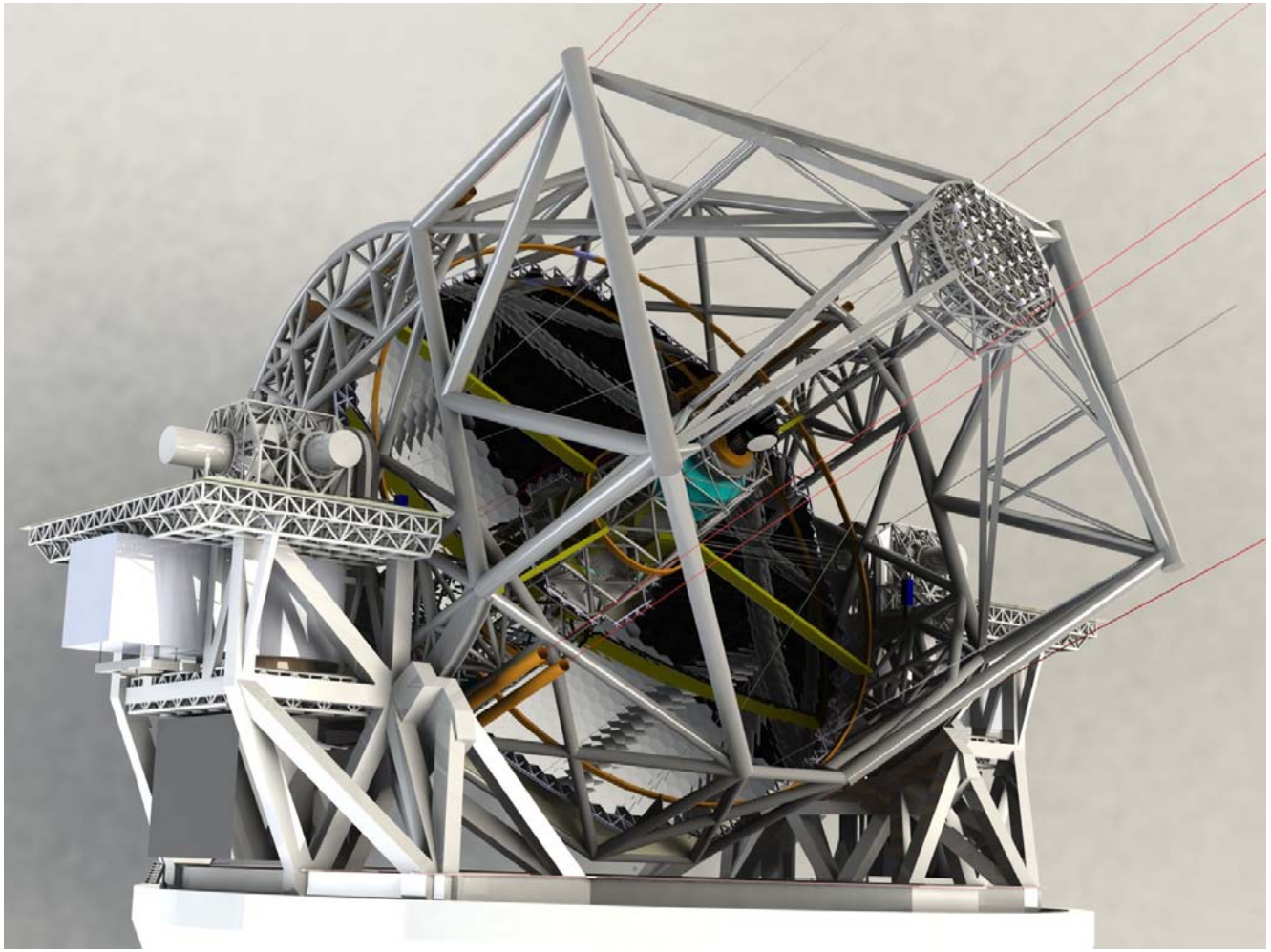
E-ELT



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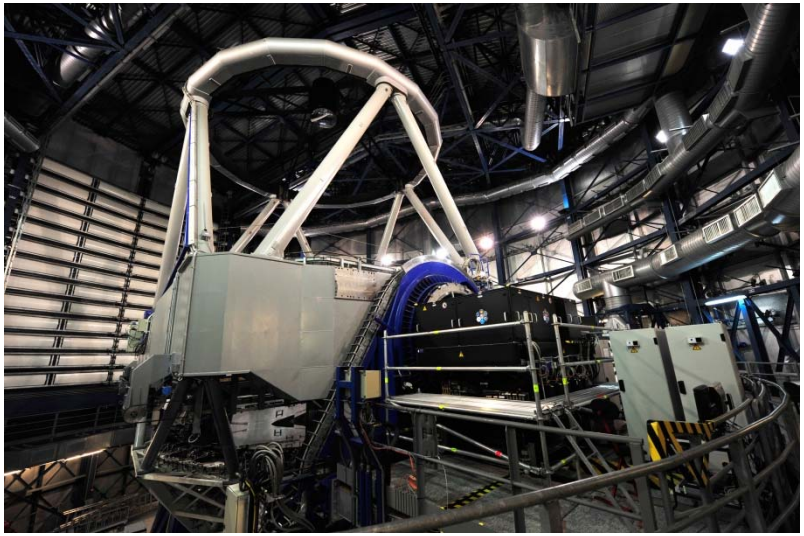
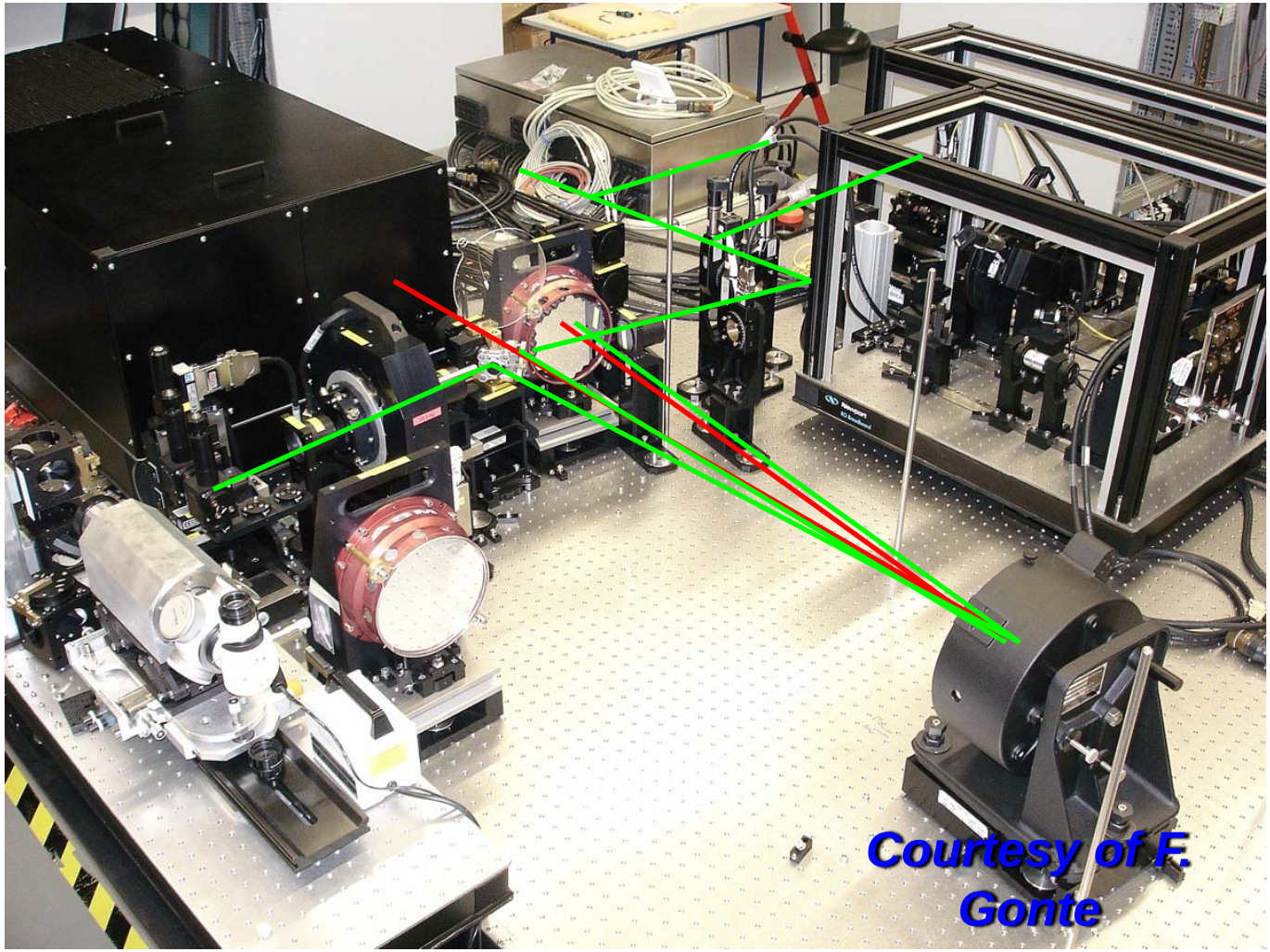
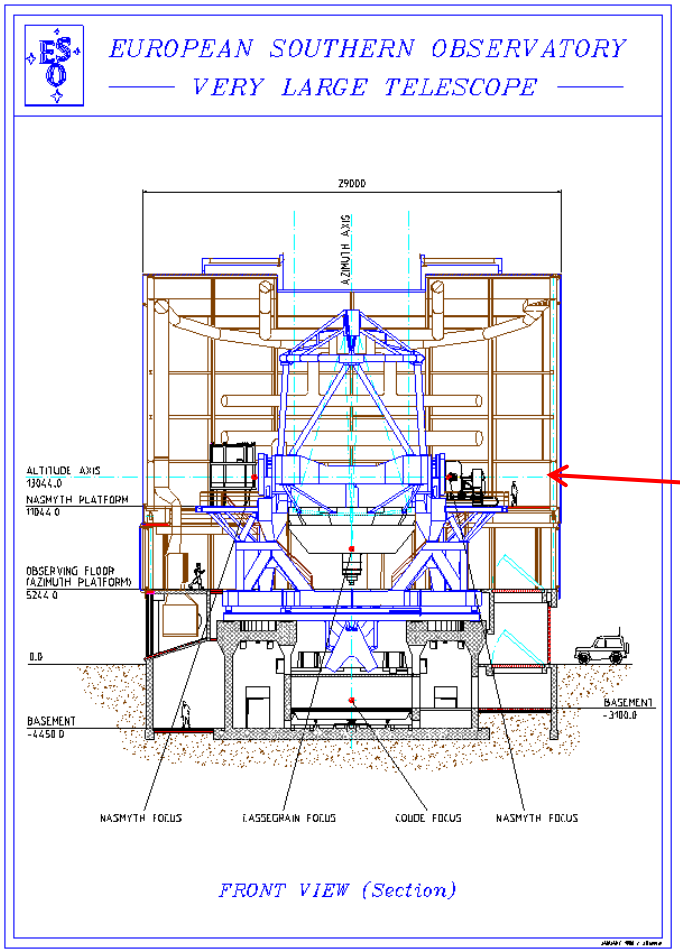
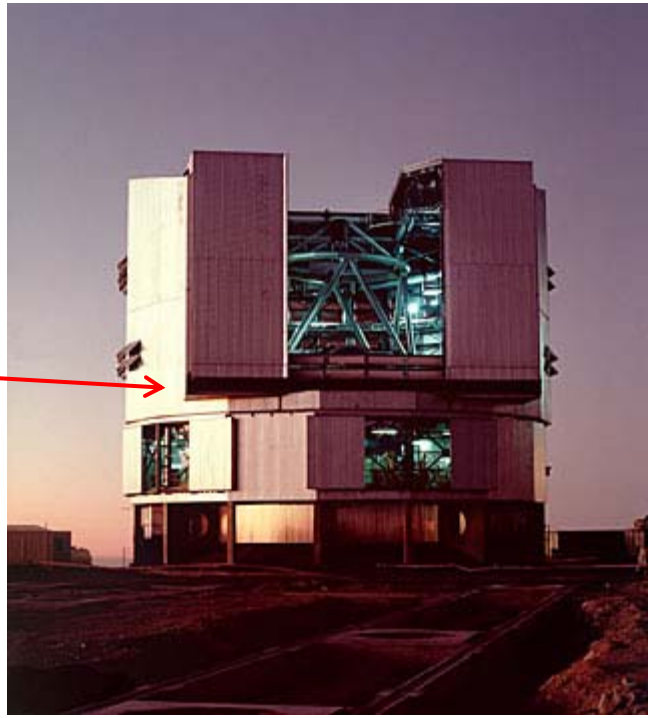
What is the challenge project about?



- System case study (since 2007)
  - APE technology demonstrator for future Extremely Large Telescope (ELT)
  - High-Tech interdisciplinary opto-mechatronical system in operation at Paranal observatory
- Goals
  - Create modeling guidelines and conventions for all system aspects, hierarchy levels, and views
  - Create fully fledged SysML model
  - **Documented at http://mbse.gfse.de**







APE was installed at telescope in Atacama desert, Chile.

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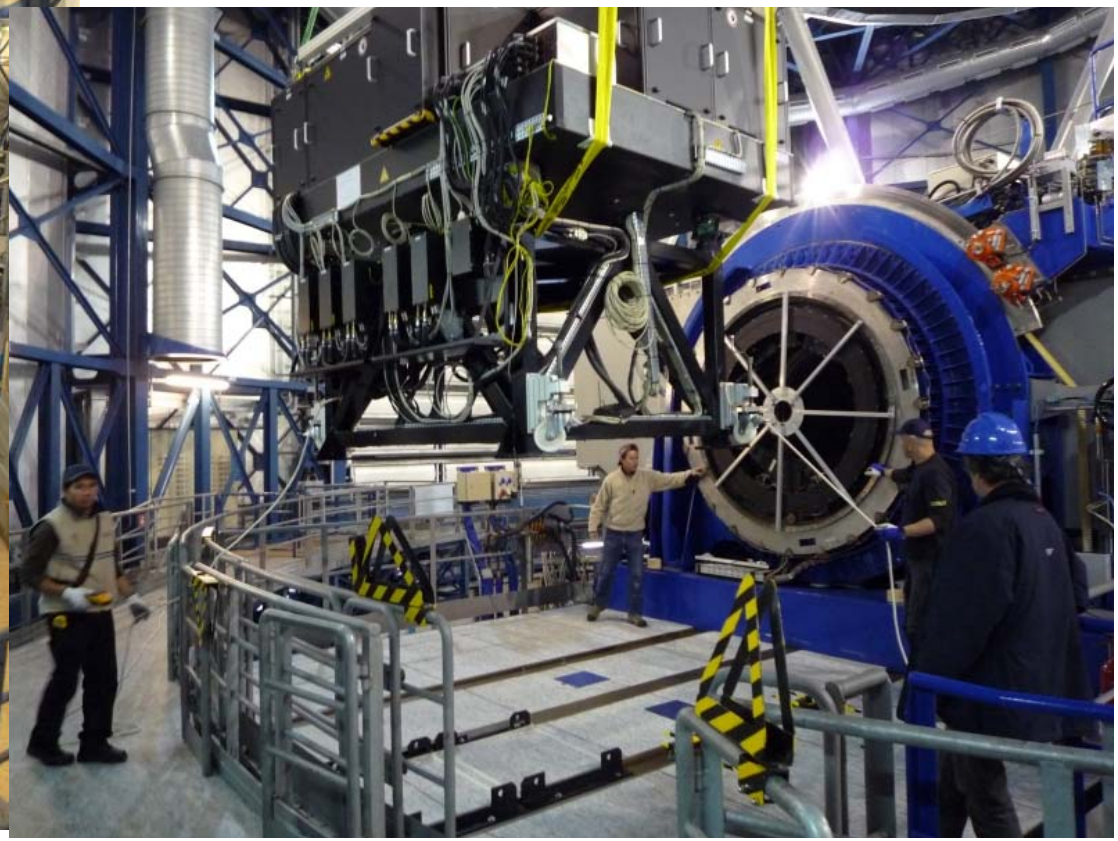
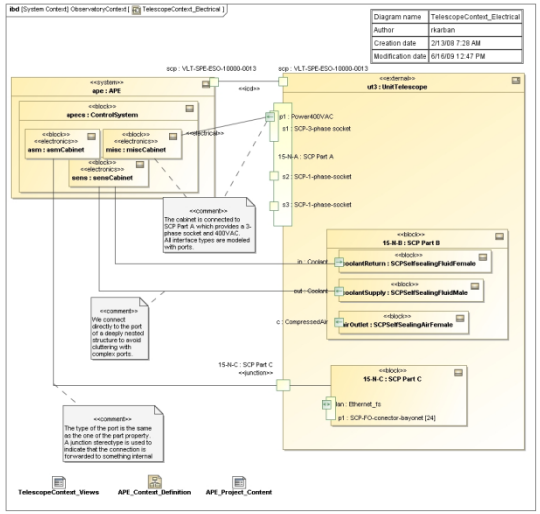
Installation on the platform of the telescope



What have we achieved?

- APE model, guidelines and best practices
  - Model structure and overview
  - Objectives and Requirements
  - Context, System Structure
  - Behavior and Data
  - Verification
  - Model library and SE Profile
- Plug-in for modeling tool



Major problems already addressed

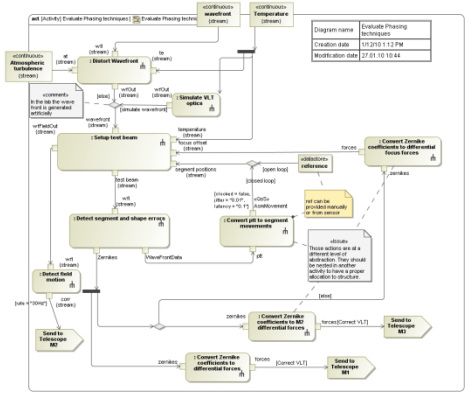
- Use properly SysML language and its elements to represent a system
  - Representative model
  - Practices and guidelines
- Scalable model organization
- Reuse of blocks (catalogue)
- Modeling challenges
  - Identified and provided feed back to RTF WGs
  - Notation (e.g. Connection of nested blocks)
  - Modelling technicalities (e.g. Grouping of interfaces, Variant modeling)
  - Tool (e.g. Configuration and Quality Control)
  - Methodology (e.g. multi-layer allocation)
- Feed back to vendor for improvement of tool
- And many more smaller problems (see guidelines)

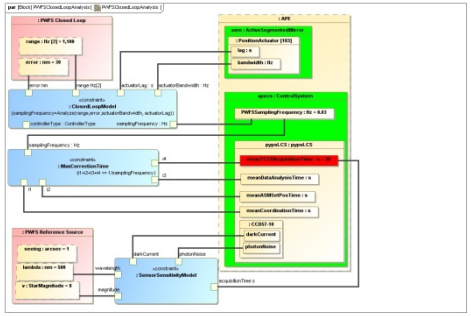
Overview of Open Issues to be addressed

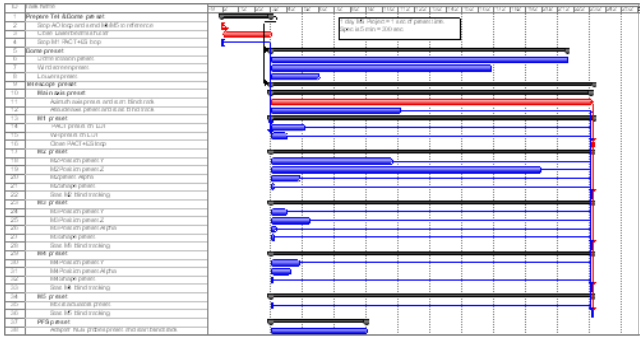
- Management of different levels of detail is hard (simple connector vs. fully develop port model)
- Allocation (e.g. behavior to structure) requires consistent levels of abstraction (which is practically not the case, in particular if different persons work on the same model).
- How does <<allocate> fit into MBSE processes
- Keeping model consistent is very hard because users have different level of know-how and levels of practice. Permanent quality control and refactoring is needed.
- Configuration control issues
  e.g. ensure consistent models across different versions of SysML and tool upgrades
- Documenting the model without cluttering the diagrams
- Finding the right information! -> organization. Problem: Users are not consistent.
- Too many options of graphical representation; terminology-> steep learning curve.
- Constraints and activities
  How can we combine activities/action, constraints, and parametrics
- Different modeling levels for different engineering disciplines (much more for electronics than for mechanics). Electrical connections and mechanical flanges. Is it really a problem?
- Metrics
  Sandy's books lists a set of metrics for models. We should see what could be useful.
- Interface modeling
  Manage different levels of details depending on engineering discipline.
  Software and electrical interfaces/parts can be modeled with a lot of detail whereas optical and mechanical interfaces/parts remain quite abstract.
- What is the physical model?
  Is the goal of the physical model a Bill of Material (BoM) or is it
  a set of variants (e.g. the baseline still contains abstract types which are specialized in each variant).
- Integration with other tools
  The SysML model is leveraged when it can be integrated with other tools to exchange information; e.g. optical parameters are traded off with electronic parameters. Bit come from different external models.
- Transition to Software (and other engineering disciplines)
  Where to stop with SW design in the System Model?
  How does it compare to mechanical design?
- Demonstrate Added value
  What are the added values? What can be done to make the model more than
  a set of consistent diagrams?
  e.g. mass roll-up, execution of parametric models, plugins to extract information (e.g. power consumption, cost).
  Parametrics versus custom plugins to extract information.
- Documentation generation
  Using SysML views and MD's engine to generate documentation from the model
- How to model physical location? E.g. a cable between Part a and Part b must be 250m long -> impact on latency -> constrain with parametrics

Issues to be solved (1/3): Combining Constraints and Activities

- Model relationships of behavioral properties and structural properties
  - Use input and output of an activity/action in parametrics
  - Use properties of activities in parametrics
- Model timing constraints between input of one action and output of another (UML DurationObservationAction, DurationTimeConstraint)
  - Show critical path; visualize duration
- System properties might impact the timing constraint

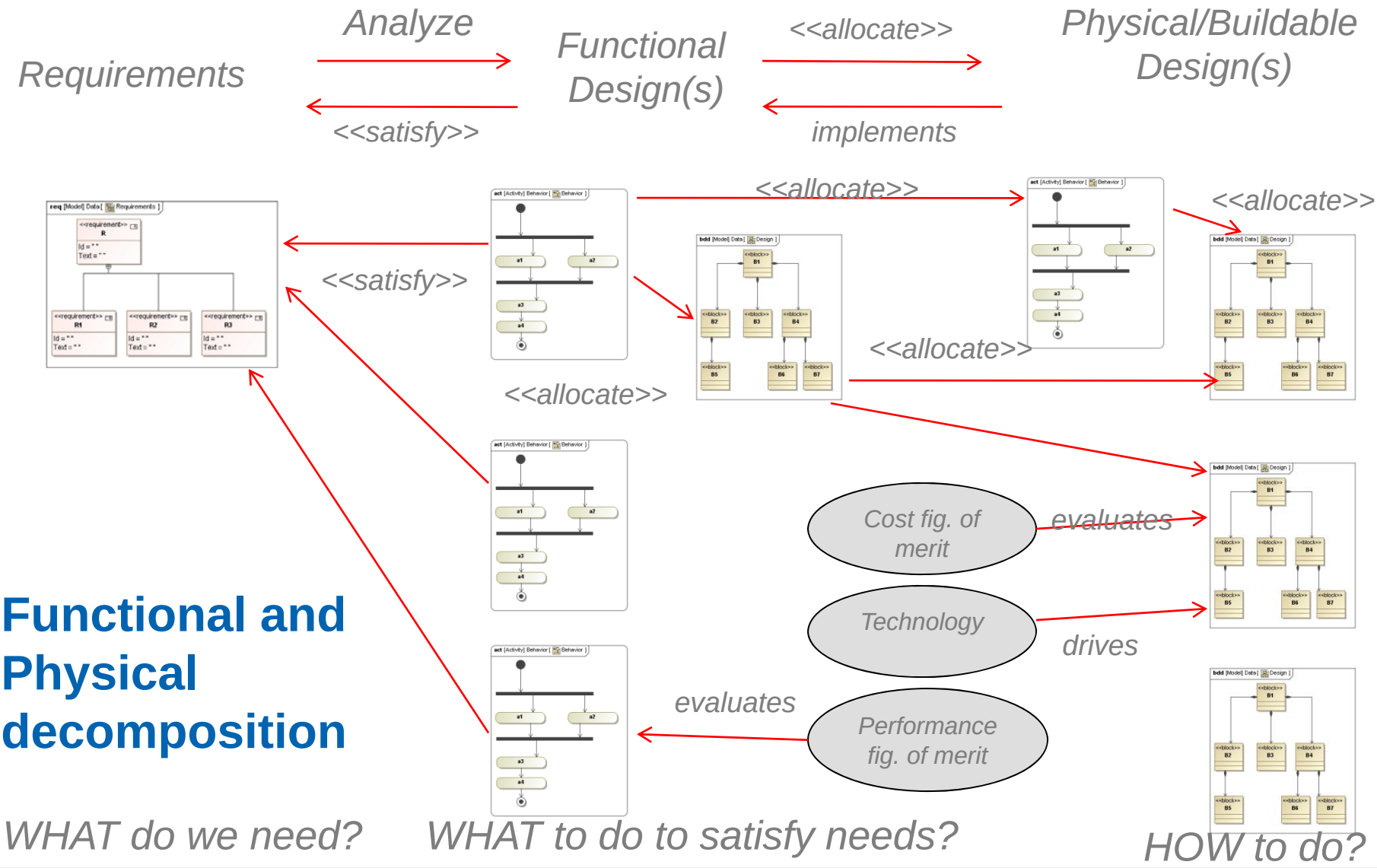






Issues to be solved (2/3): How does <<allocate> fit into MBSE processes?

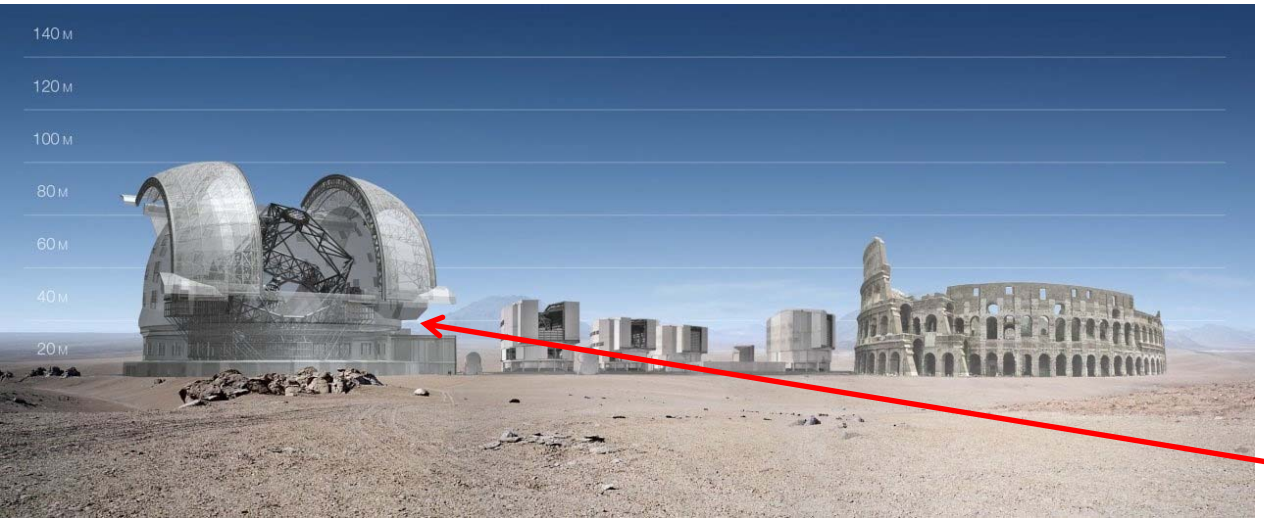
- SysML semantics and Process are not independent
- Handle different levels of abstraction (functional and structural) and usage
  - Different levels make allocation more difficult
  - Different persons work on the same model
- Define rules for usage of allocation which fit with the process; configure tool to check those rules.
- Define semantics of allocation (e.g. action to part, abstract part to concrete block)
- Establish guidelines when to use e.g. action to part or activity to block
- MBSE processes existed before SysML and need to take into account its evolution

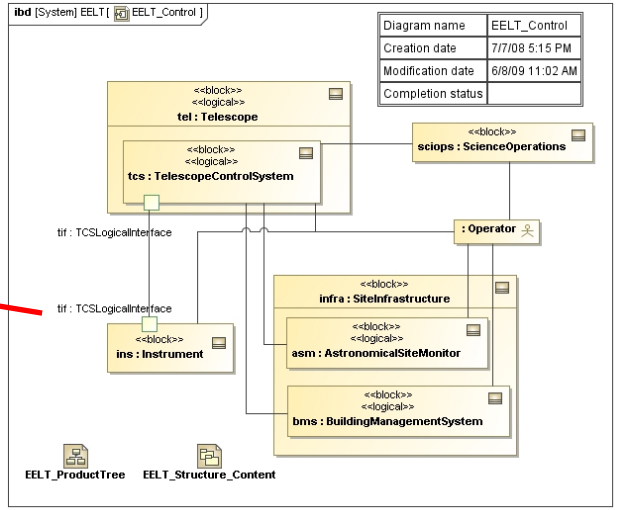


Issues to be solved (3/3): What is the physical model?

- What is goal of the physical model:
  - Bill of Material (BoM) where e.g. abstract parts are composed of concrete parts
  - Structure of (abstract) physical parts which become a BoM, using a
    - Set of variants (baseline is abstract and abstract types are specialized) or
    - Set of allocations (allocate abstract types to concrete parts)
- Manage different levels of details depending on engineering discipline.
  - Software and electrical interfaces/parts can be modeled with a lot of detail
  - Optical and mechanical interfaces/parts remain quite abstract (mass, size)
- How to model physical location?
  e.g. cable between Part a and Part b must be 250m long -> impact on latency -> constrain with parametrics
  - CAD model provides information on distance, requirement defines required latency, constraints model their relation to model the required network topology and technology

Applying Practices and Guidelines





- 10000 tons of steel and glass
- 20000 actuators, 8000 mirrors
- 60000 I/O points, 700Gflops/s, 17Gbyte/s
- Many distributed control loops, excessive control strategy
- Use SysML to model the control system, since 2008

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What is next?

- Update and elaborate guidelines and best practices
- Create a product – **MBSE SysML Handbook**
  - Navigable SysML reference model integrated with applied guidelines and best practices
  - Automatically generated booklet on guidelines and best practices
- Elaborate APE reference model
- More applications of variant modelling and parametric modelling
- Enhance integration of modelling with MBSE process
- Create examples and guidelines for open issues

Live Demo of the Model

- Please fasten seatbelts - setting up the system…