Telescope systems modelling by SE^2

INCOSE German Chapter

GfSE

Overview

- Introduction
- Problem statement
  - Object of case study
  - Why using SysML
  - Goals
- Technical approach
- Expected deliverables
- Collaboration approach
- Intermediate results (problems)

Introduction

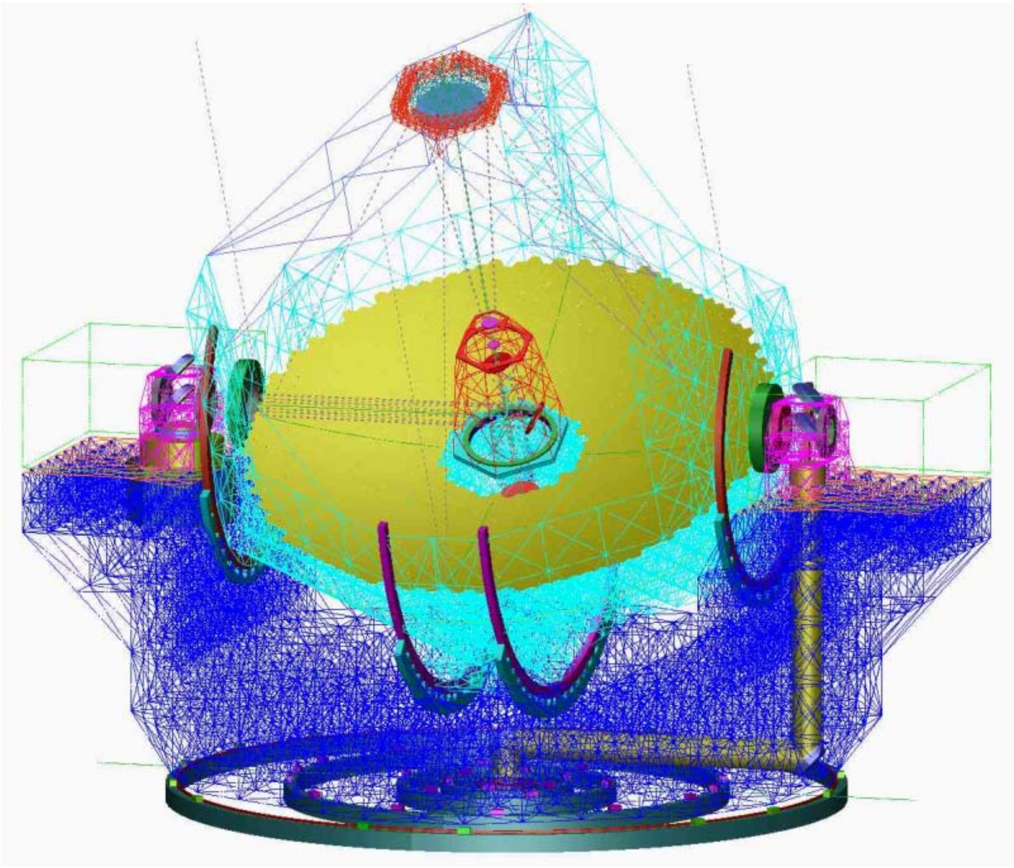
- The SE^2 team is a collaboration between the European Southern Observatory (ESO) and the SysML working group of the German Chapter of INCOSE.
- ESO provides access to one of its high-tech projects funded by the European Union.

Problem statement - Object of case study

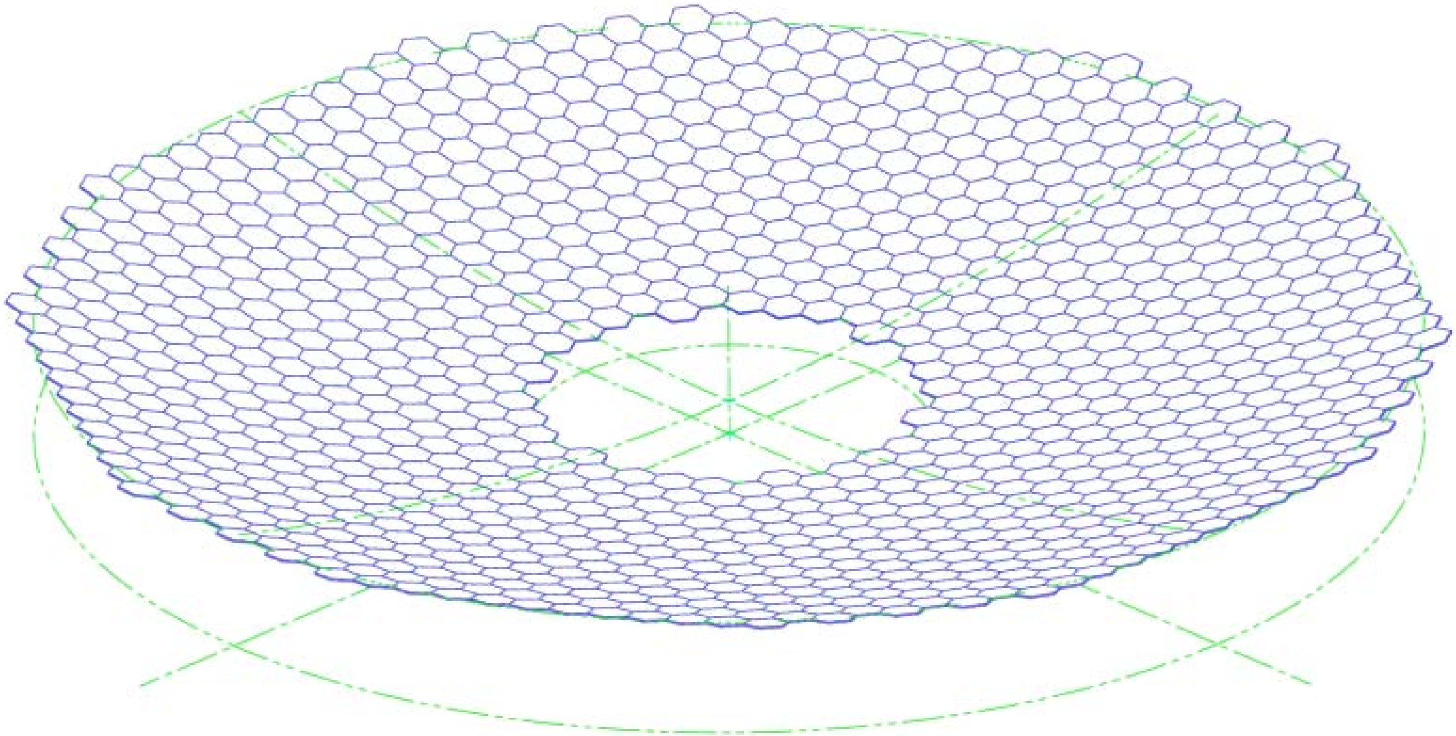
Active Phasing Experiment (APE)

- Validate wave front control concepts
- Four different types of sensors to be compared
- Optical, mechanical, electronic, software components and interfaces
- Multi-national/multi-institute collaboration with industrial contracts
- Deployment in the lab and on sky
- Installation/Integration on existing telescope in the Atacama desert (optical, mechanical and control system integration)
- Status: integrated in the lab, close to completion

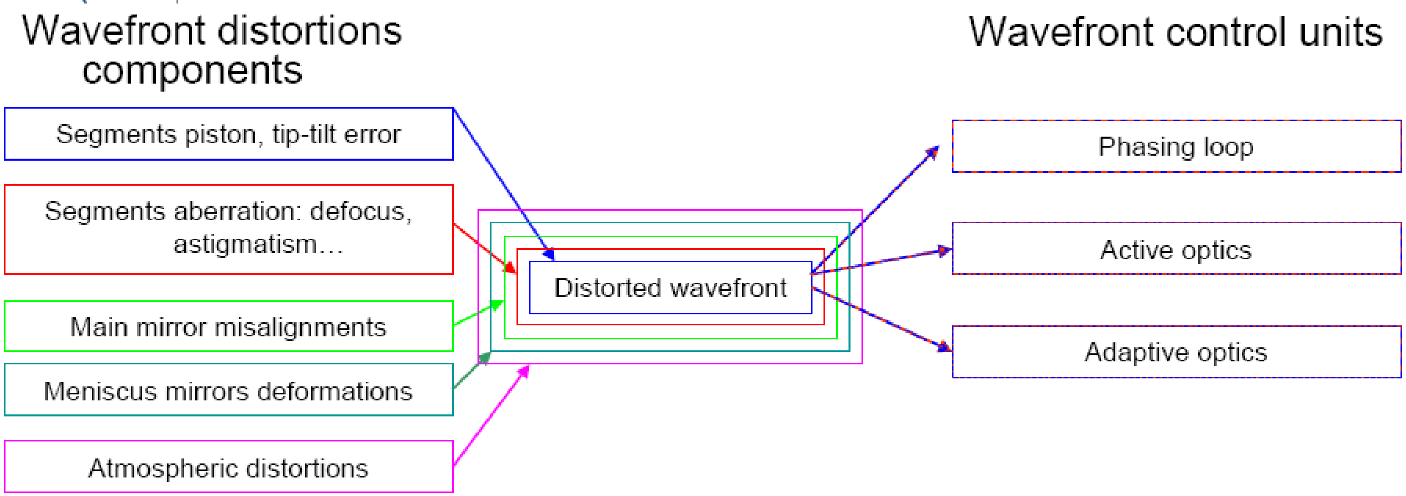
E-ELT mechanical structure



Segmented primary mirror



Segmented Telescope Wavefront Control

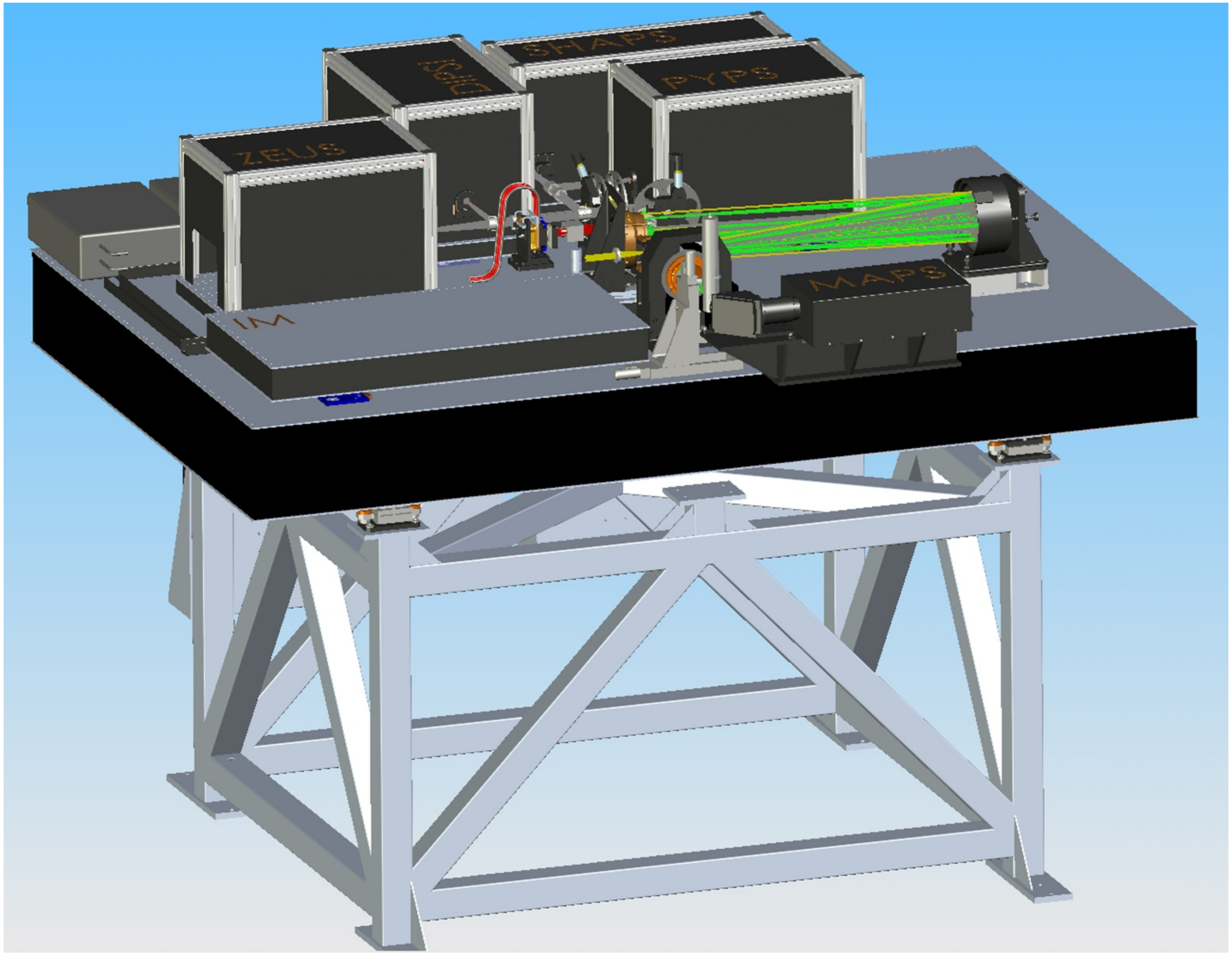


Separation of the components according to temporal and spatial spectra

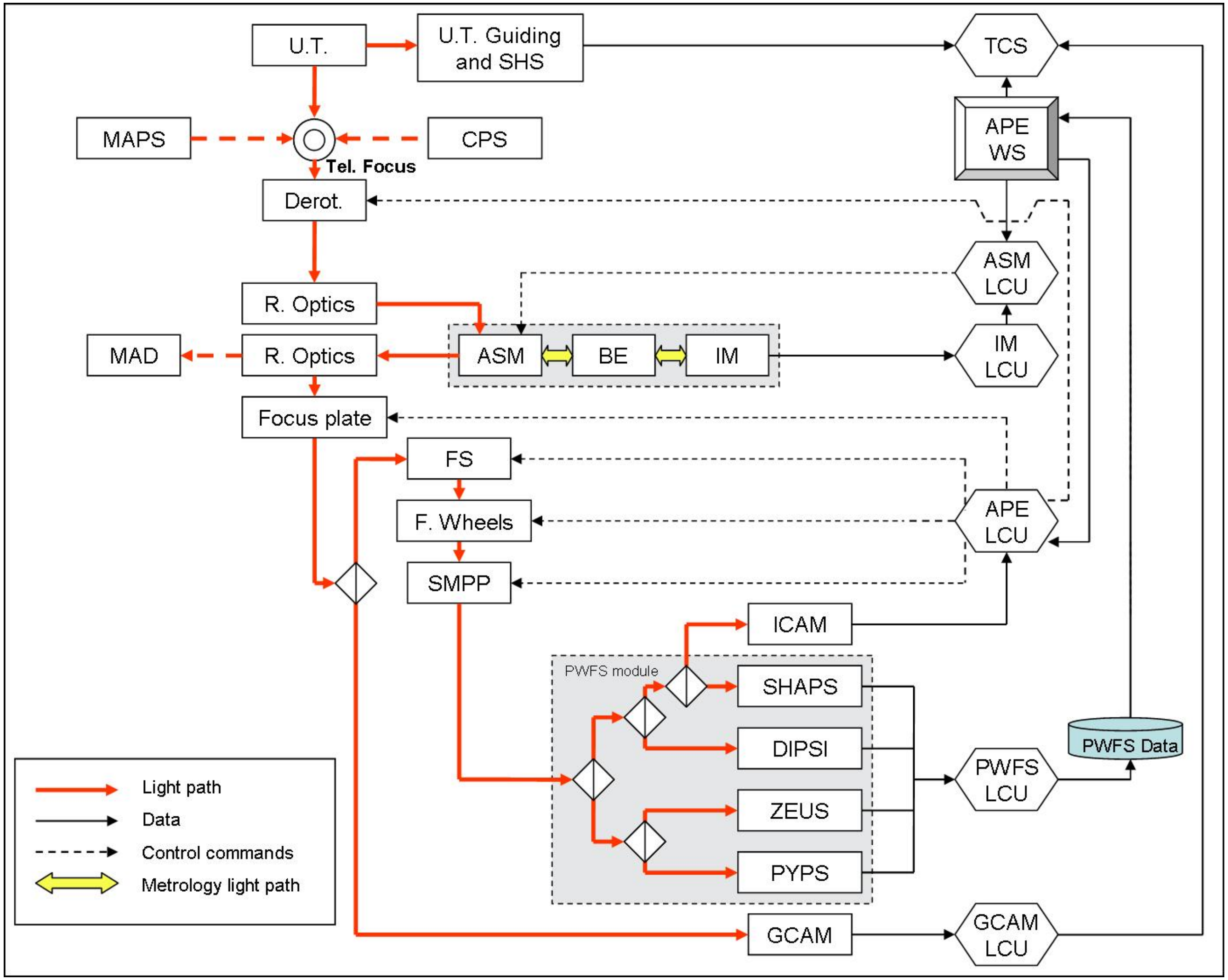
Control strategy: which unit responsible for which component

Phasing sensor baseline: atmospheric distortions are external noise

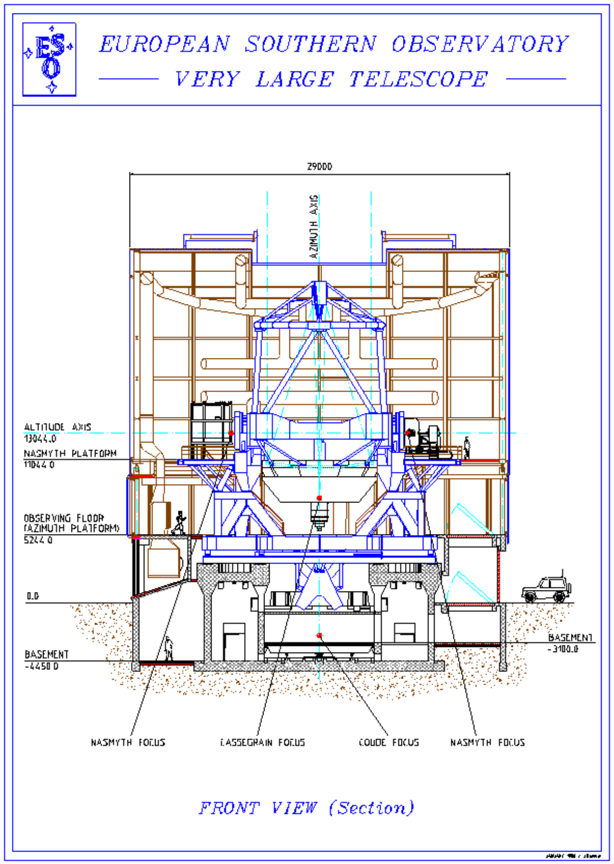
APE 3D View



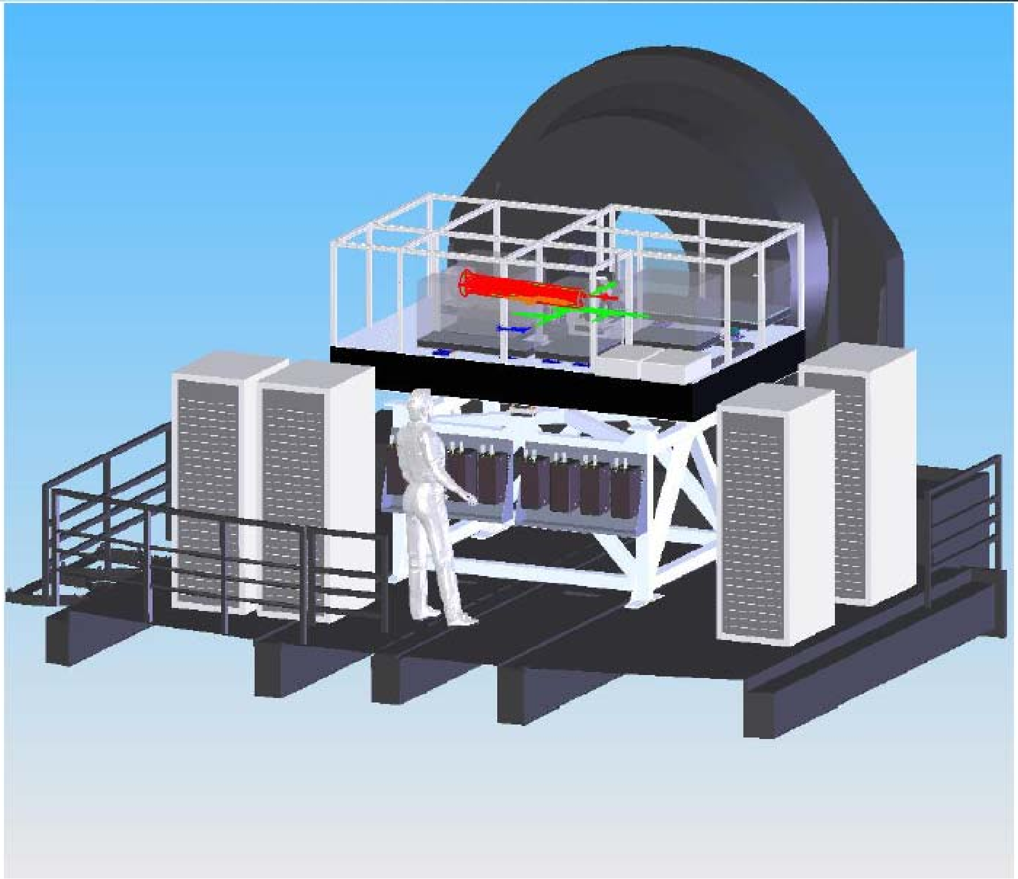
APE Block Diagram



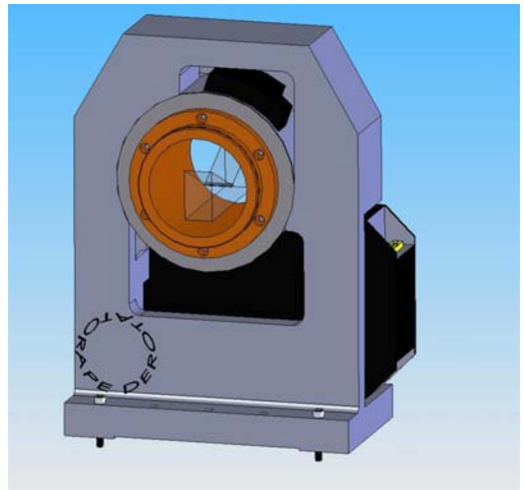
Very Large Telescope

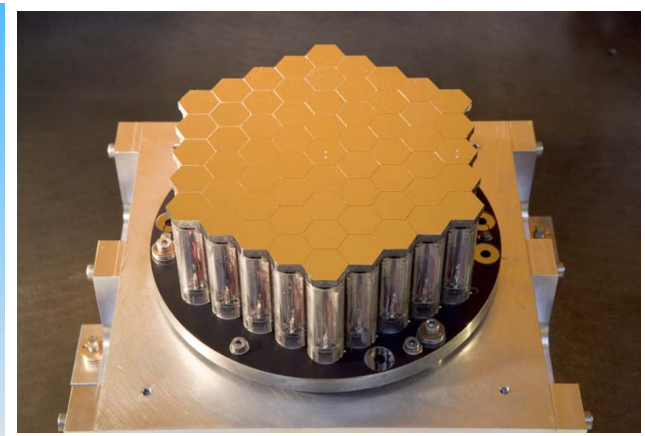


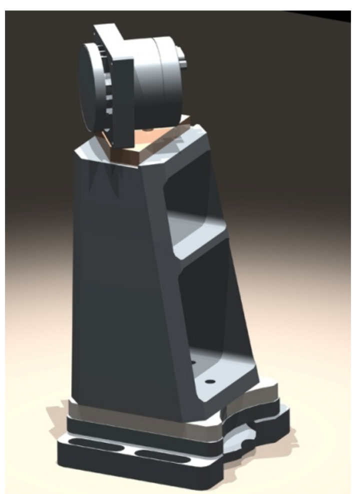
APE on the Nasmyth platform

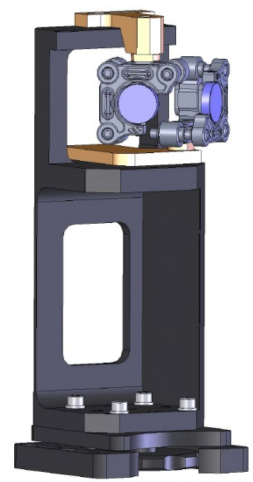


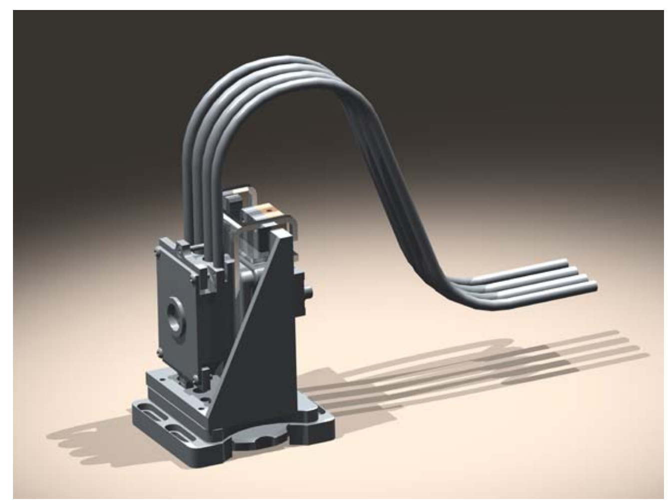
Design of APE sub-components



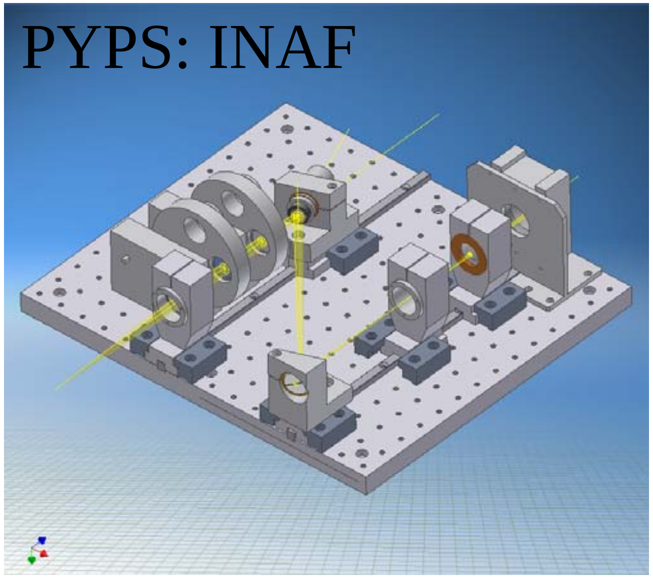


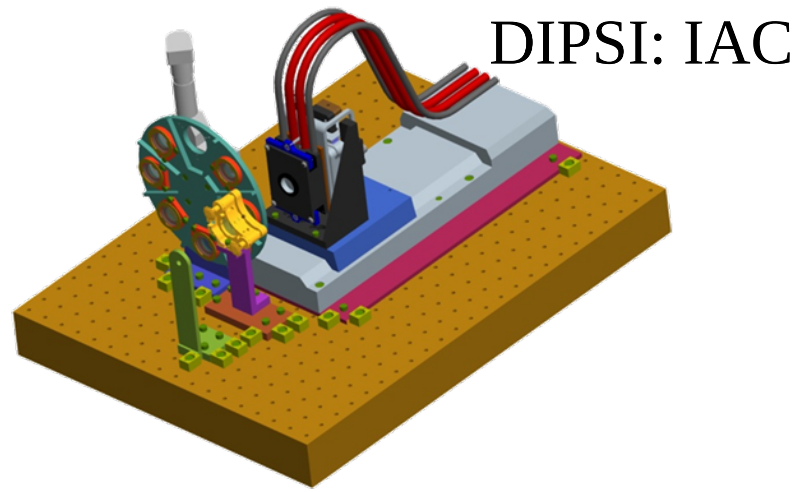


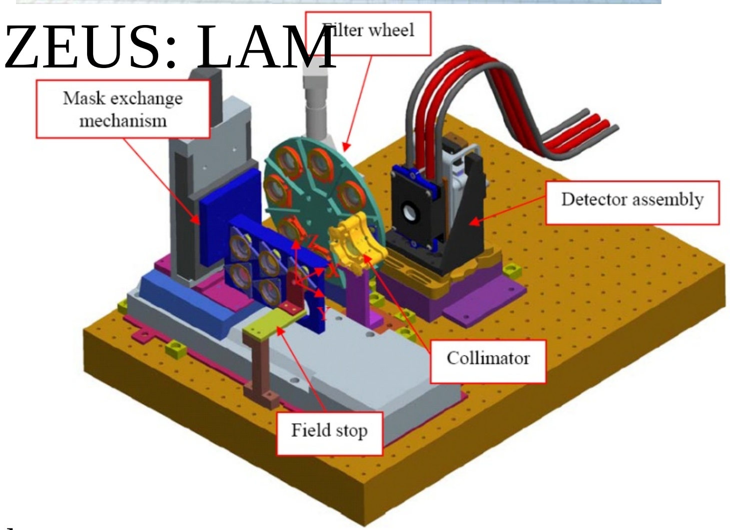


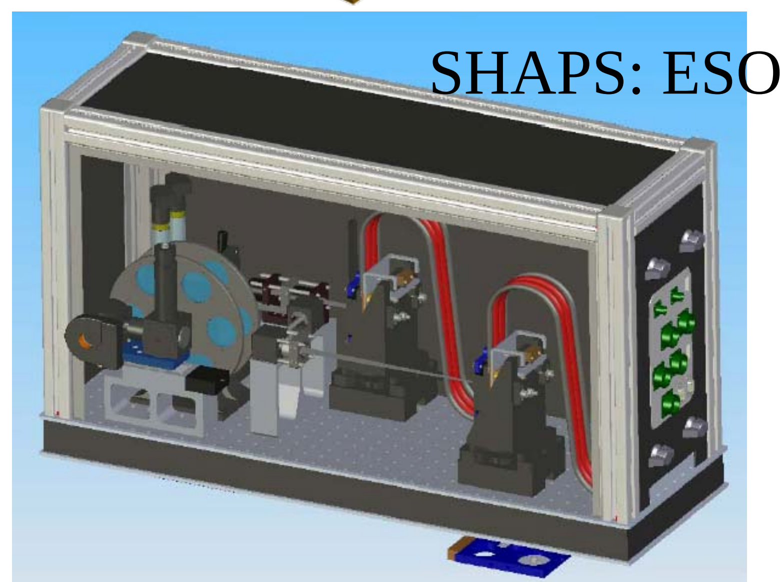


Phasing Wave front Sensors

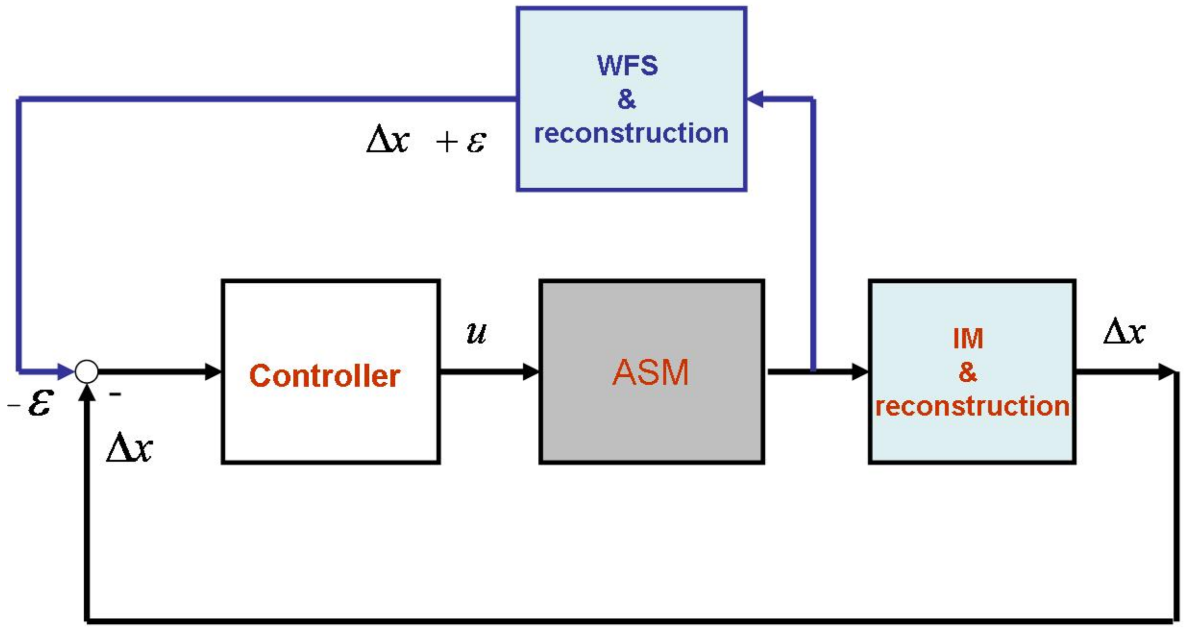






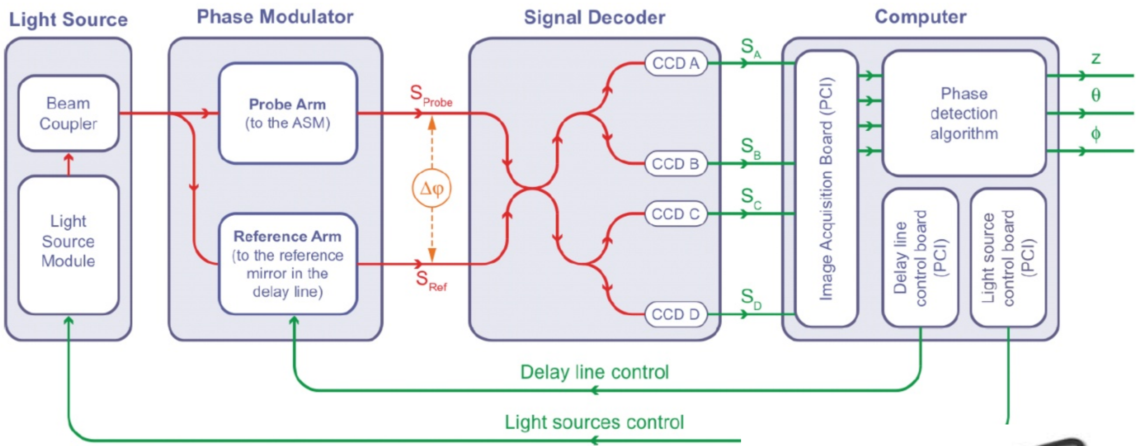


Control loop



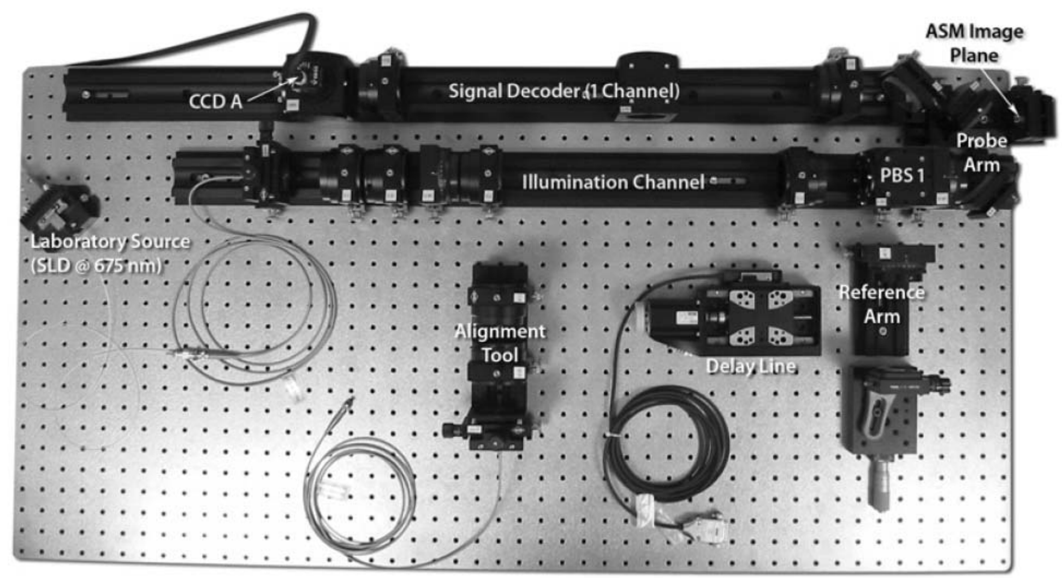
The control of the ASM has a cascade structure with two loops.

Internal Metrology



Fogale Nanotech

SPIE 6267-86



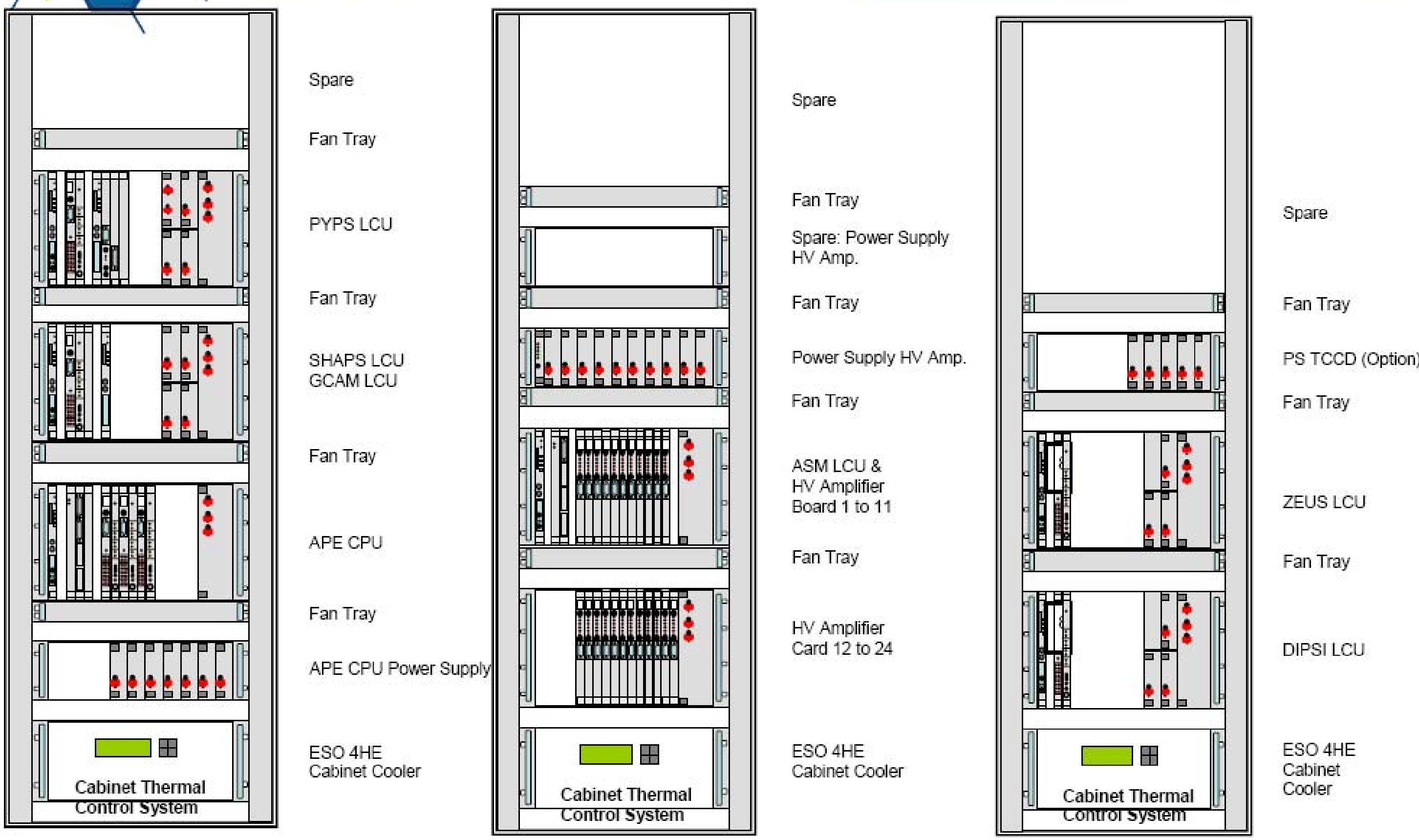
OMB

3*2*0.305 m^3.

Classical support in lab.

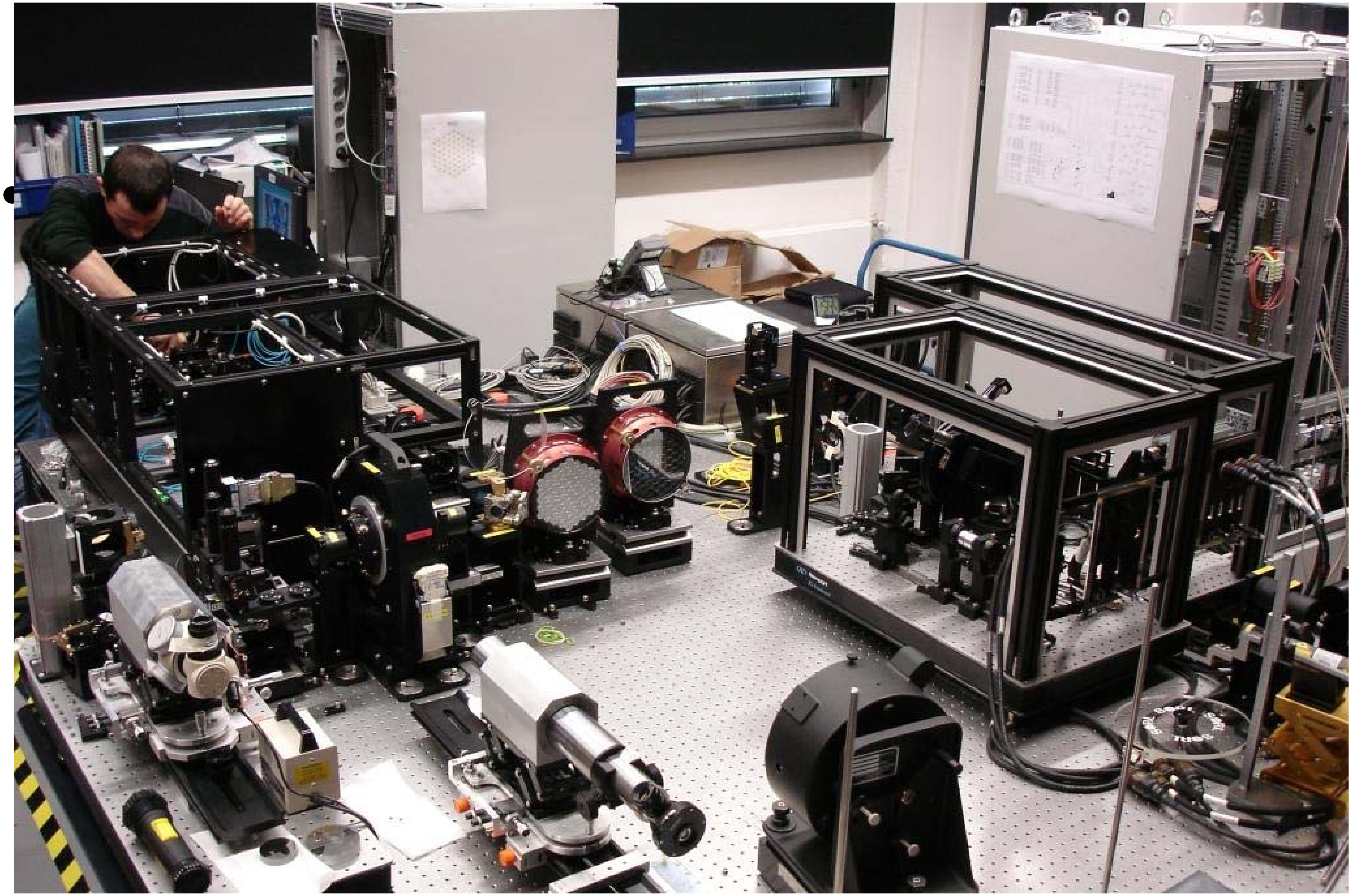
Specific structure for the UT.

Cabinets



Spare
Fan Tray
PYPS LCU
Fan Tray
SHAPS LCU
GCAM LCU
Fan Tray
APE CPU
Fan Tray
APE CPU Power Supply
ESO 4HE
Cabinet Cooler
Cabinet Thermal
Control System
Spare
Fan Tray
Spare: Power Supply
HV Amp.
Fan Tray
Power Supply HV Amp.
Fan Tray
ASM LCU &
HV Amplifier
Board 1 to 11
Fan Tray
HV Amplifier
Card 12 to 24
ESO 4HE
Cabinet Cooler
Cabinet Thermal
Control System
Spare
Fan Tray
PS TCCD (Option)
Fan Tray
ZEUS LCU
Fan Tray
DIPSI LCU
ESO 4HE
Cabinet
Cooler
Cabinet Thermal
Control System

APE in the lab



Problem statement - Why using SysML?

- Large number of functional, performance, physical and interface requirements
- All kinds of optical, mechanical, electronic and software interfaces
- Highly demanding optical layout
- Significant amounts of data
- Different functional aspects active depending on the deployment mode

Problem statement - Goals I

The SE^2 manifesto

Provide the systems engineer the means to state the system problems comprehensively, to ensure that all requirements for a system are satisfied throughout the life cycle of the system and to develop a model on the basis of which a real system can be built, developed or deployed (i.e. design a system) (W. Wymore, Model-Based Systems Engineering 1993)

Problem statement - Goals II

The concrete SE^2 goals are:

- Provide examples of SysML, common modelling problems and approaches.
- Build a comprehensive model which serves as the basis for providing different views to different engineering aspects and subsequent activities.
- Demonstrate that SysML is an effective means to define common concepts.
- Demonstrate that a SysML model enhances traceability.

Technical Approach Basics

- The approach to the problem is primarily top-down.
- The approach is a rough guideline and not a solid plan.
- It's NOT a waterfall approach. It's an iterative approach.
- The model shall include at least two abstraction levels.

Technical Approach
Steps I

- Describe the objectives of the system and the modelling
- Determine the requirements
- Describe the context of the system, i.e. it's actors
- Find the services of the systems, i.e. the use cases
- Model the use case control and object flows with all important variants and exceptions

Technical Approach
Steps II

- Define the domain values and blocks
- Derive a system design
- Describe system blocks behaviour
- Describe parametric model

Expected deliverables I

- Modelling FAQ
  - Guidelines for the use of modelling elements (e.g. use of ports and flows)
  - Allocation strategies
  - Guidelines for the definition of system hierarchies
- Heuristics for using the requirements relationships
- Naming conventions
- Scalable model structure and organisation
- Analysis model

Expected deliverables - Example

Type	Electrical	Mechanical	Hydraulic	Optical	Human-Machine	Data	Thermal
Interaction medium	<<connector>> Item Flow=Current	<<connector>> Item Flow=Force	<<connector>> Item Flow =Fluid	<<connector>> tem Flow=Photons	<<connector>> Item Flow=Information (e.g. audio, visual, finger print, iris), mechanical force	<<connector>> Item Flow=n/a	<<connector>> Item Flow=Heat
Connector	<<Flow Spec>>, e.g. RS232, USB, CAN, Ethernet, <<Block>>, e.g. cable	<<Block>>, e.g. Joint coupling, flange, pipe	<<Block>>, e.g. Valve	<<Flow Spec>>, e.g. air, Fiber optic connectors	<<Block>>, e.g. Display	<<Flow Spec>>, e.g data I/O items	<<Block>>, e.g. metallic foil bundle
Isolator	<<Block>>, e.g. RF shield insulator	<<Block>>, e.g. Shock mount bearing	<<Block>>, e.g. Seal	<<Block>>, e.g. Shutter	<<Block>>,e.g. cover window	n/a	<<Block>>, e.g. air
Converter	<<Block>>, e.g. Antenna A/D converter	<<Block>>, e.g. Gear Train Piston	<<Block>>, e.g. Reducing valve Pump	<<Block>>, e.g. Lens group	<<Block>>, e.g. Keyboard, lever, loudspeaker, steering wheel, touch screen	<<Block>>, e.g. FPGA	<<Block>>, e.g.Peltier

Collaboration approach

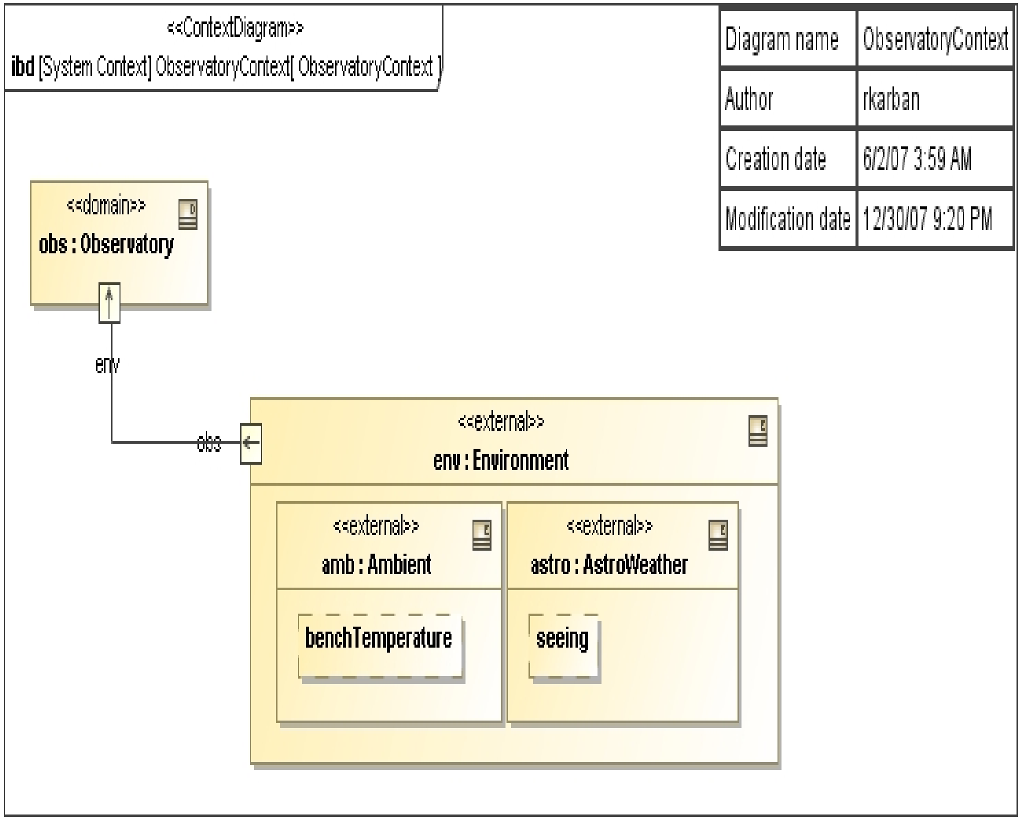
- **Constraints**
  - Participants are from different organisations
  - Geographically widely distributed, very limited time available
  - Different technological background, different interests
- **Approach**
  - Set-up common online collaboration area, common repository
  - Define common goals and objectives
  - Small task force for the “constitution”
  - Define available resources, schedule, tasks, results and priorities
  - Define rather independent standalone tasks
  - Organise regular workshops and telecons
  - Establish online connection with a messenger service

Intermediate results (problems)

- Context diagrams
- Model Structure

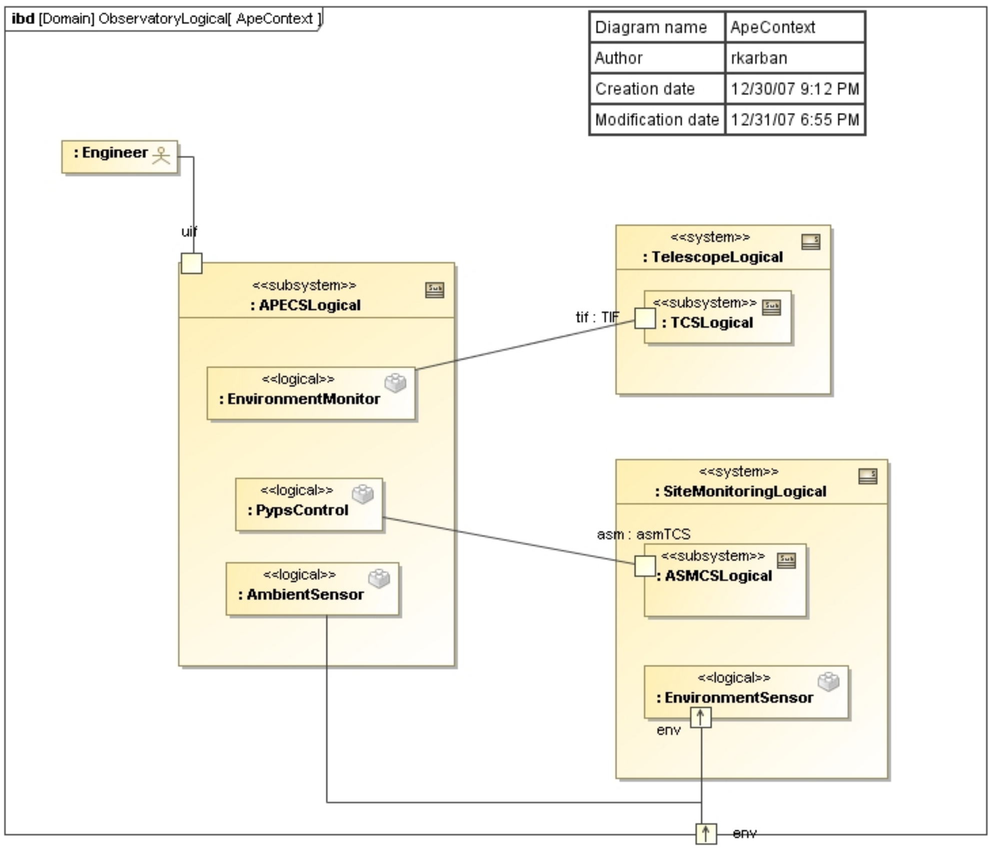
Their content is neither complete nor necessarily correct!

Context diagrams I



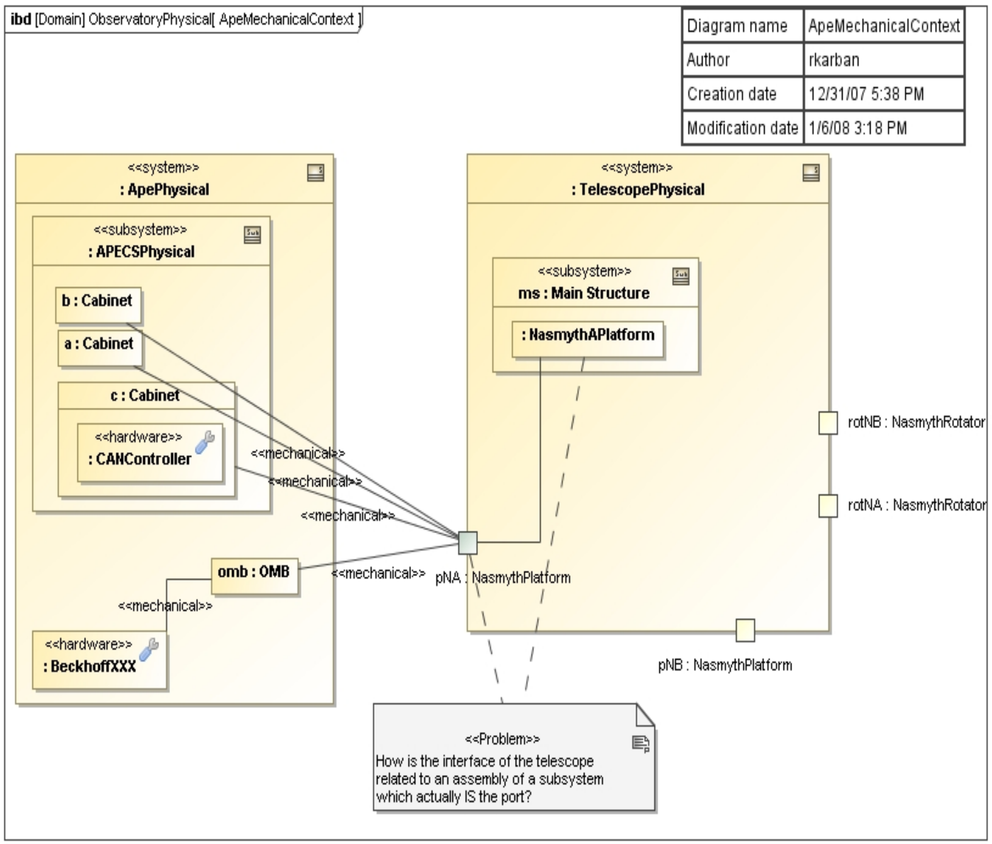
- Observatory context
- Model environmental properties

Context diagrams II



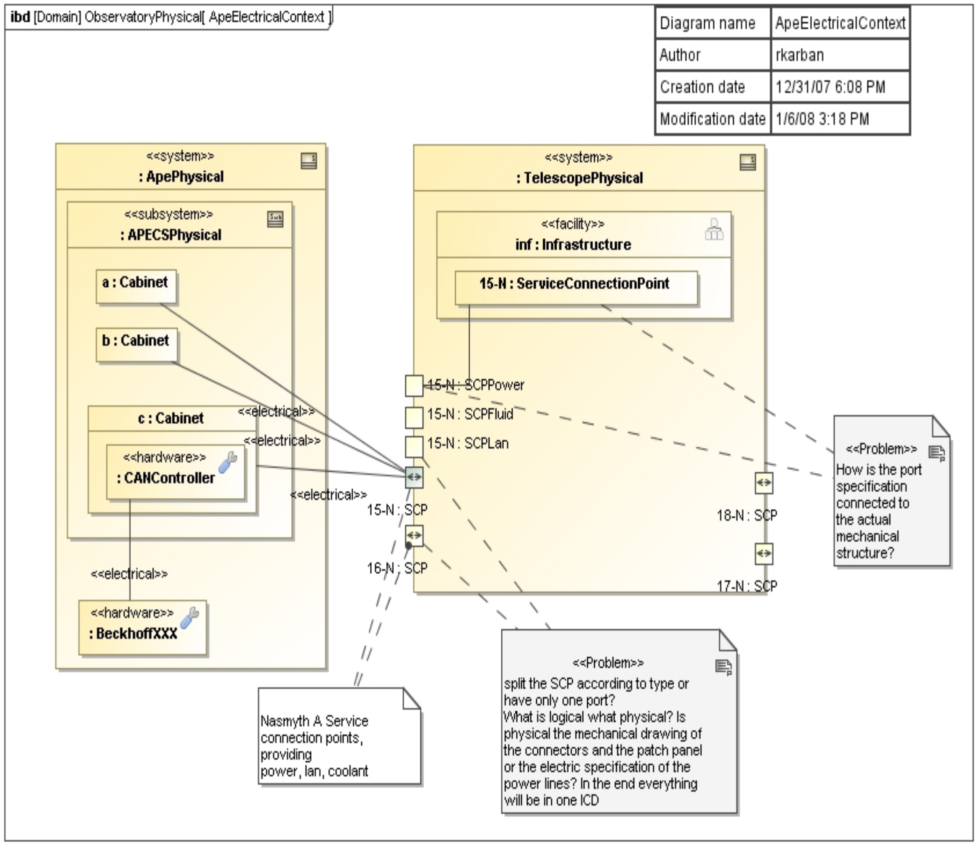
- APE Control System logical context

Context diagrams III



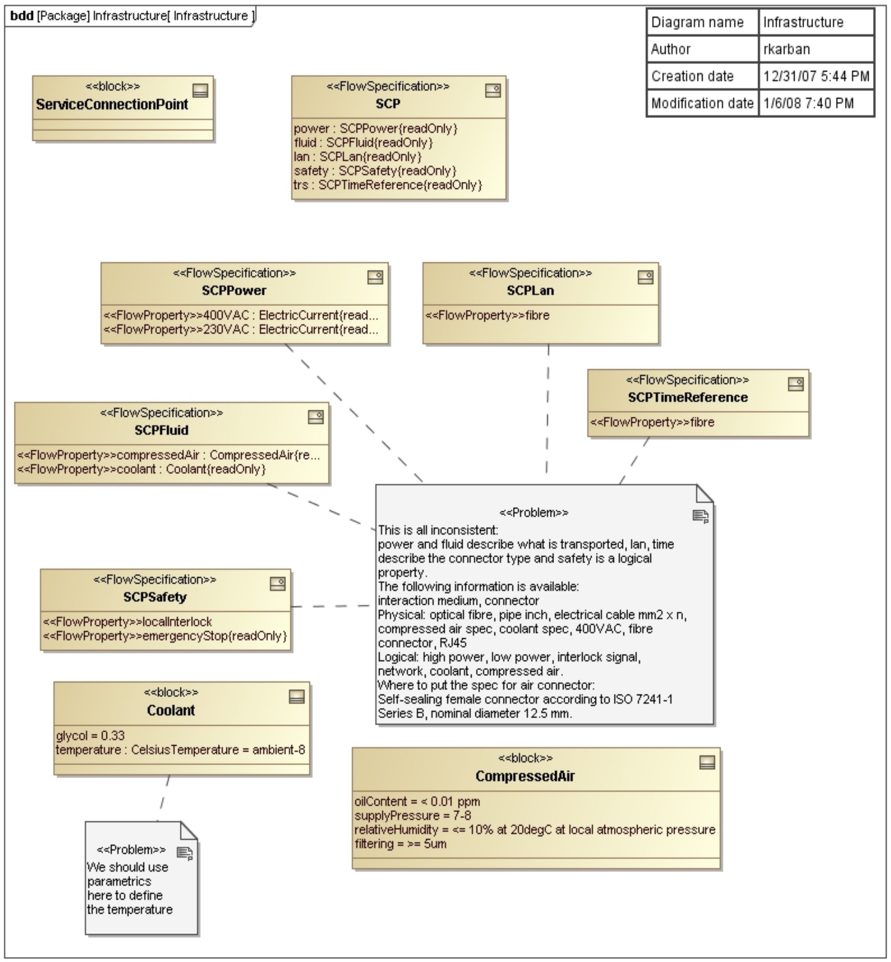
- APE Mechanical Context
- Modelling of hierarchies and interfaces

Context diagrams IV



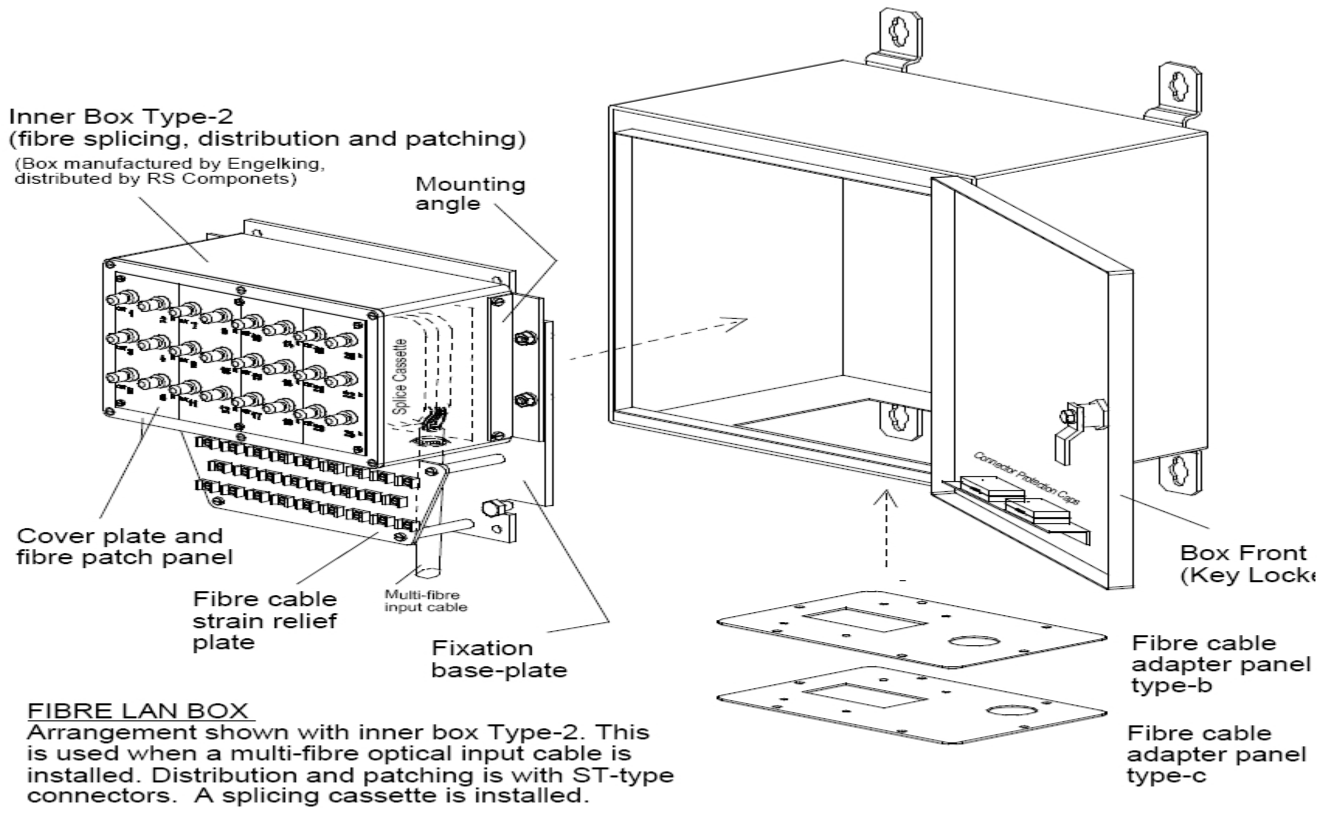
- APE Electrical context
- Modelling of hierarchies and interfaces

Flow Specifications I

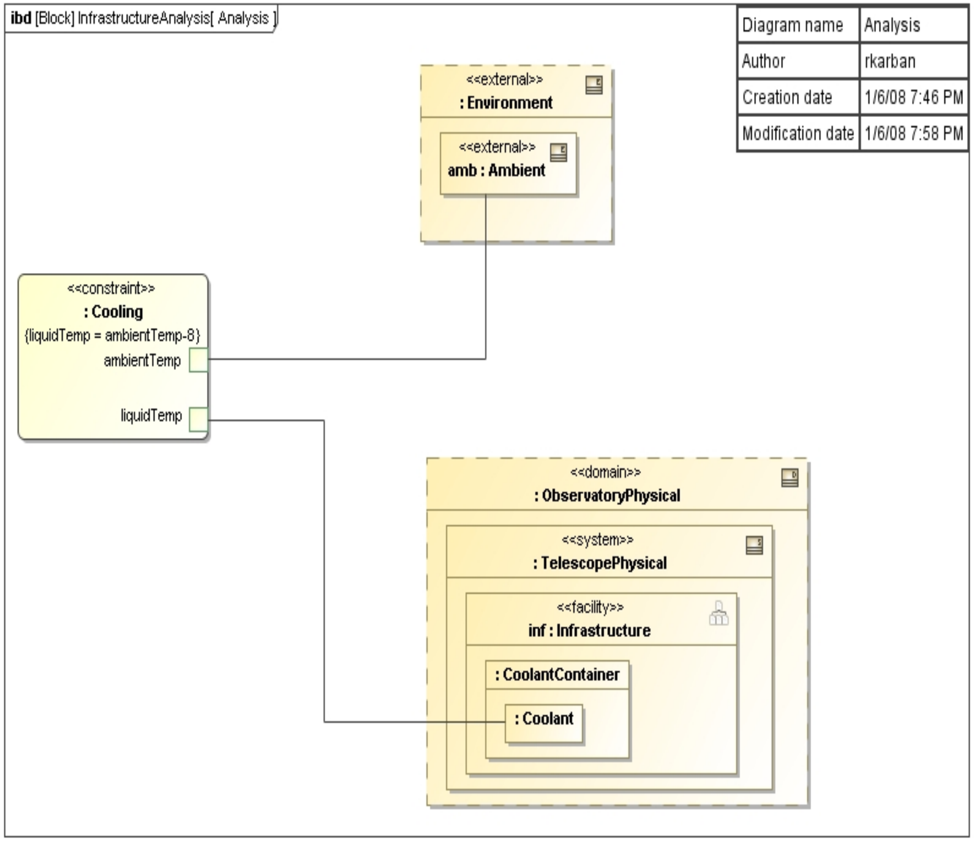


- Flow Specification BDD
- Model of a real VLT Service connection point providing coolant, compressed air, Lan, electrical and safety connections
- Modelling consistent views of the various parts
- Relationship to "real" schematics

Flow Specifications II

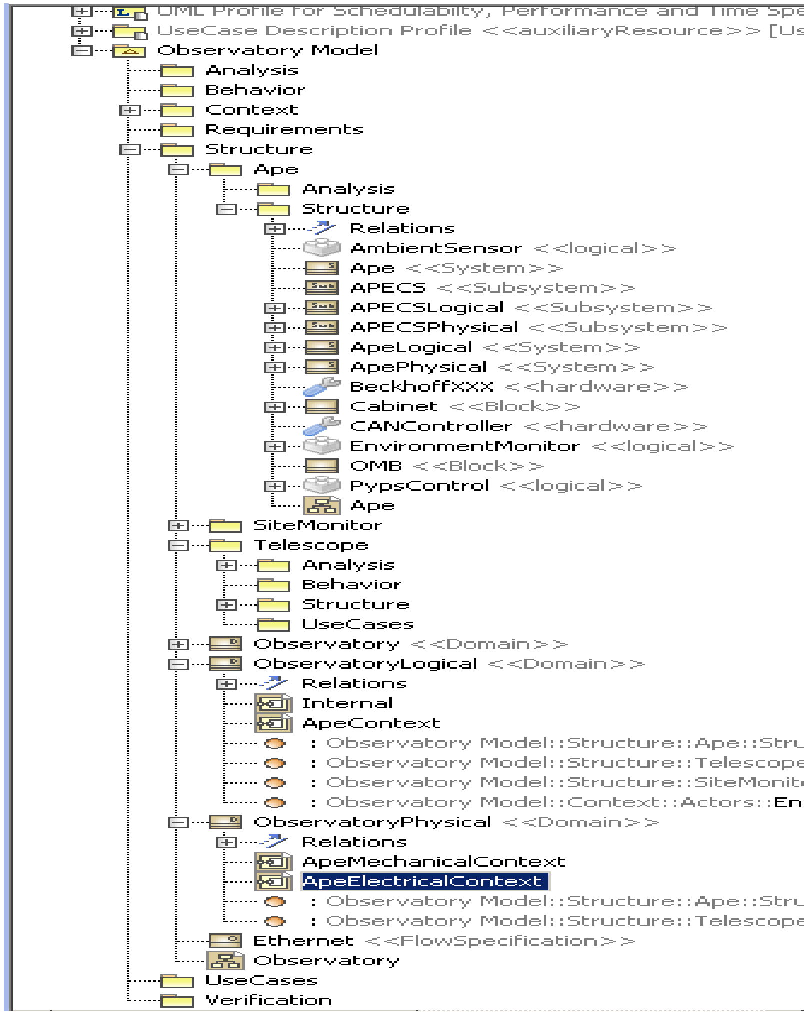


Parametrics model



- Open Issue:
  Can parametrics contain dynamic aspects?

Model structure



- Possible model structure covering context and internal information with different abstraction layers

Conclusions

- Project:
  - APE seems well suited for a case study showing SysML application and benefits
- Anticipated problems
  - Model consistently different views
  - Find a common modeling philosophy for team members from different domains (even worse for distributed modeling)
  - Find all necessary information in the project documentation

INCOSE International Symposium in the Netherlands in June 15-19 2007 Challenge Team Results

- Solution and supporting models
- MBSE practices used
- Configuration management approach
- Tools and environment
- Degree of execution
- Model interchange capabilities
- MBSE metrics
  - Resource requirements (effort, time, ..)
  - MBSE value (productivity, quality, …)
- MBSE findings, issues, and recommendations
  - Validation of enablers and inhibitors from MBSE strategy (refer to Jack Ring Strategy under the MBSE IW08 / MBSE Roadmap Planning)
- Training material
- Plan forward