HIRES: Welcome and Introductory meeting

System Engineering Team and Activities for Phase B

12-13 Jan 2022

MRI introduction

- HIRES initiative
- Hires blue book (2013-2016)
- Hires Phase-A (2016-2018)
- Hires pre-Phase B (2019-2021)

Overall concept

The design of an instrument operating from the blue to the K band requires different detector technologies to be encompassed in the design not to mention the different required temperature regimes, e.g. cryogenic environment in the K band. A modular fibre-fed cross dispersed echelle spectrograph is considered as a promising concept to be deeply studied

General description

The possible overall concept is summarized in figure 1. The light from the telescope is split, via dichroics, into N wavelength channels. Each wavelength channel includes several telescope optical interfaces that feed, through separate groups of fibres, a dedicated spectrograph module. Each telescope-interface and fibre-bundle corresponds to an observing mode. Based on a preliminary analysis we consider four spectrograph modules as shown in Figure 1 but both the number of spectrograph and splitting in wavelength may change following the dedicated trade-off study during Phase-A.

Modules location

The split in wavelengths over the modules is influenced, among all other parameters by the optical transparency of the different types of fibres available on the market; therefore, the different modules can be positioned at different distances from the telescope focal plane.

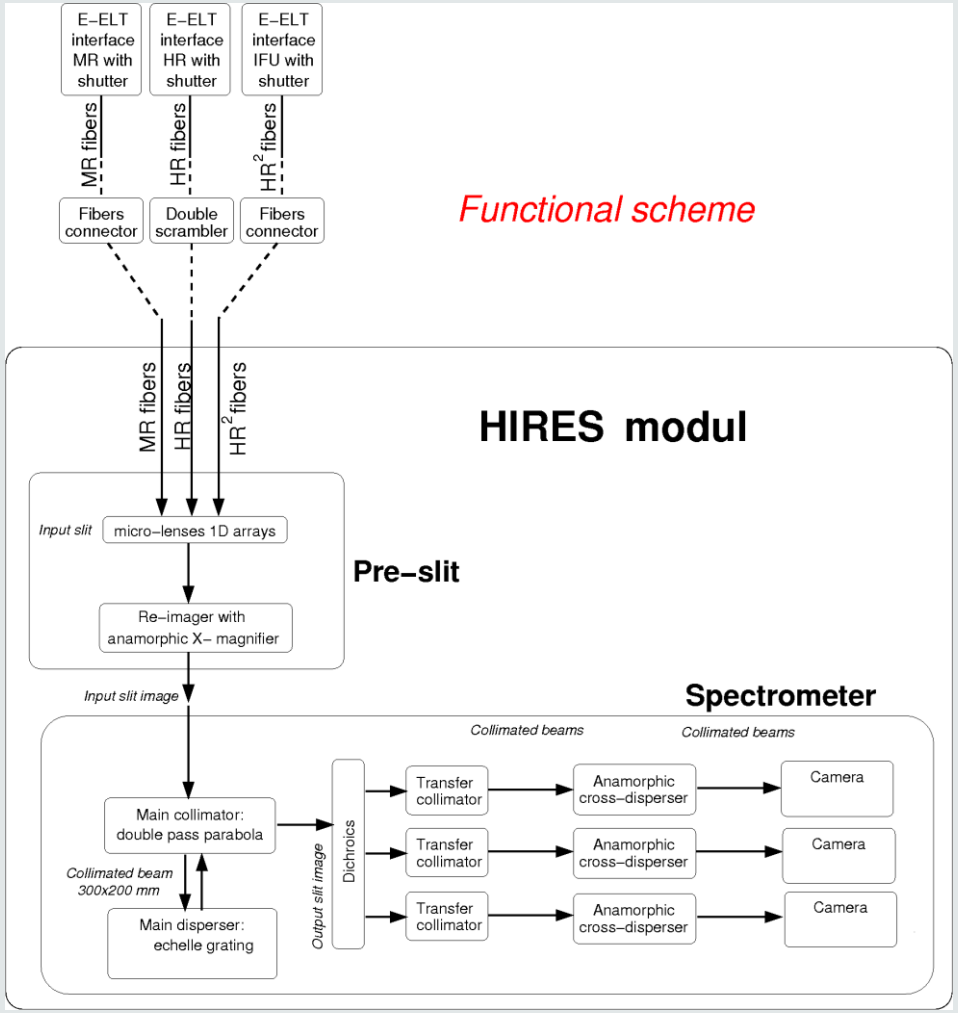
Observing modes

All spectrometer modules have a fixed configuration, i.e. no moving parts inside the spectrometers. They include a series of parallel entrance slits, each generated from a separate set of fibres that, in turn, determines the observing mode. The definition of the baseline observing modes will be carried out during phase-A study.

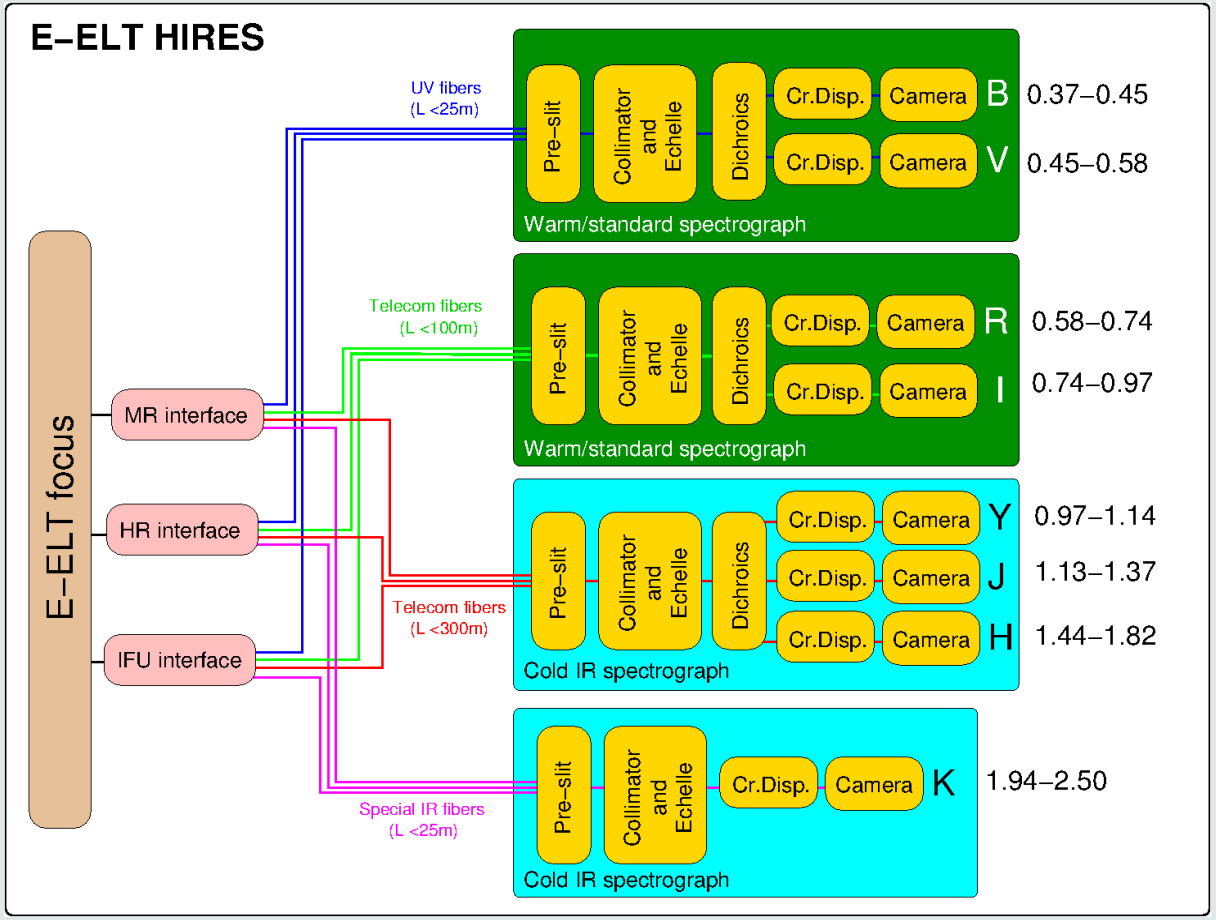
Blue book Requirement

Requirement	HR Single Obj. Mode	MR Multiplexed Mode	HR AO-assisted IFU
Spectral Resolution	>= 100'000	10'000-20'000	>= 100'000
Multiplexing	1	1-10 (few arcmin FoV)	IFU
Spectral coverage (μm)	0.37-2.5		
Minimum Blue wavelength	370 nm		
Allowed wavelength gaps	No substantial		
Wavelength calibration	Espresso template for the VISible, TBD for IR		
Stability	10cm/s for VIS (goal 2cm/2), TBD for IR	n.a.	10cm/s
throughput	Espresso template for the VISible (12%), ECHO template for IR (8mag s/n 10'000 per res element in 100min or better)	Espresso template for the VISible (12%), ECHO template for IR (8mag s/n 10'000 per res element in 100min or better)	Espresso template for the VISible (12%), ECHO template for IR (8mag s/n 10'000 per res element in 100min or better)
Polarimetry	Preferrable	n.a.	n.a.

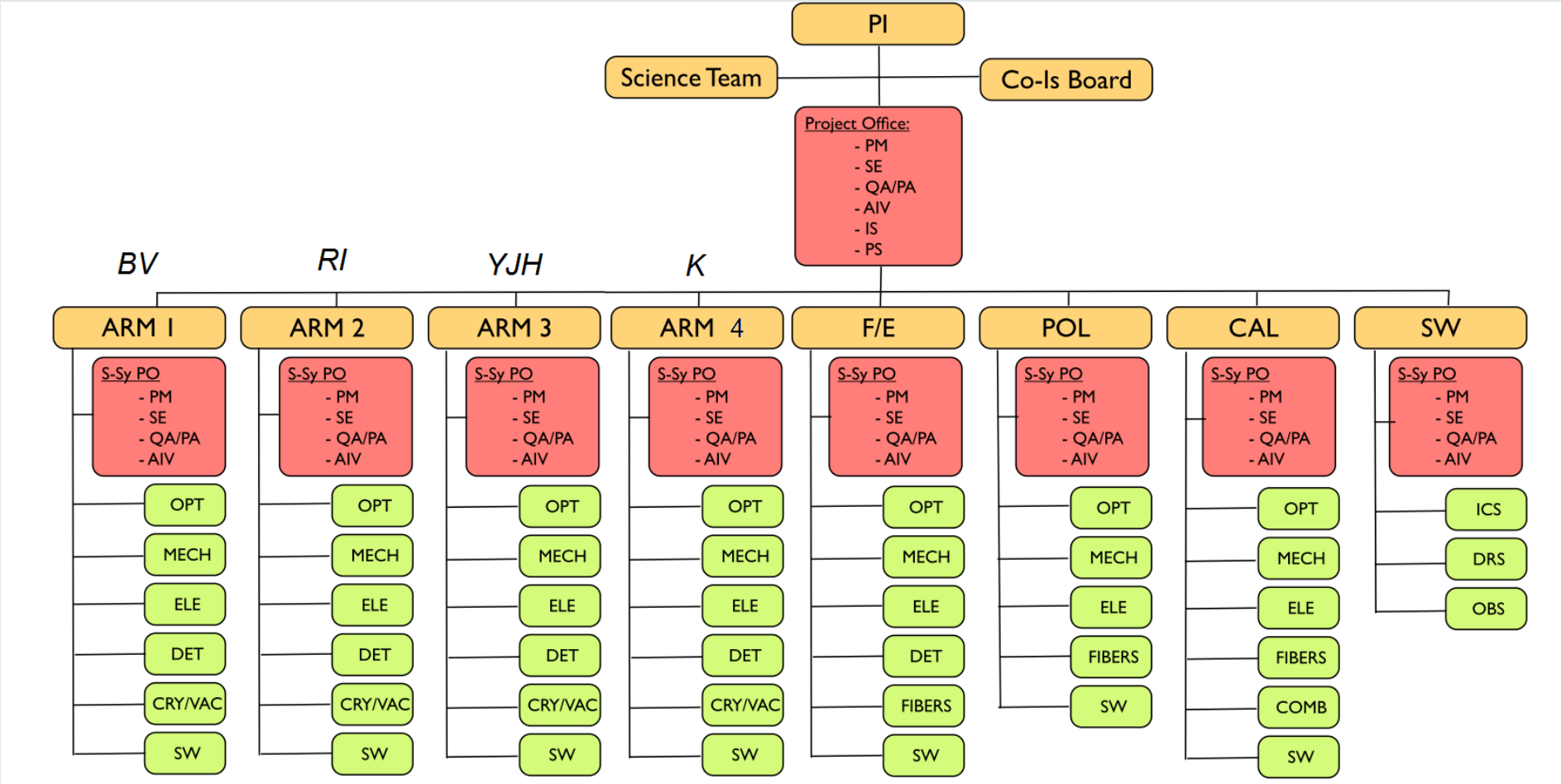
Blue book Functional scheme



Blue Book Architecture



Blue Book WBS



Blue Book Conclusion

- Hires can be modulated to provide reasonable fraction of the required science **with almost ANY early 1st light of ANY ELT.**
  - + Hires is feasible
  - + Time adaptability (different module timeline)
  - + Location adaptability
  - + Any Telescope pupil
  - + No AO dependence
  - + No Mass issue

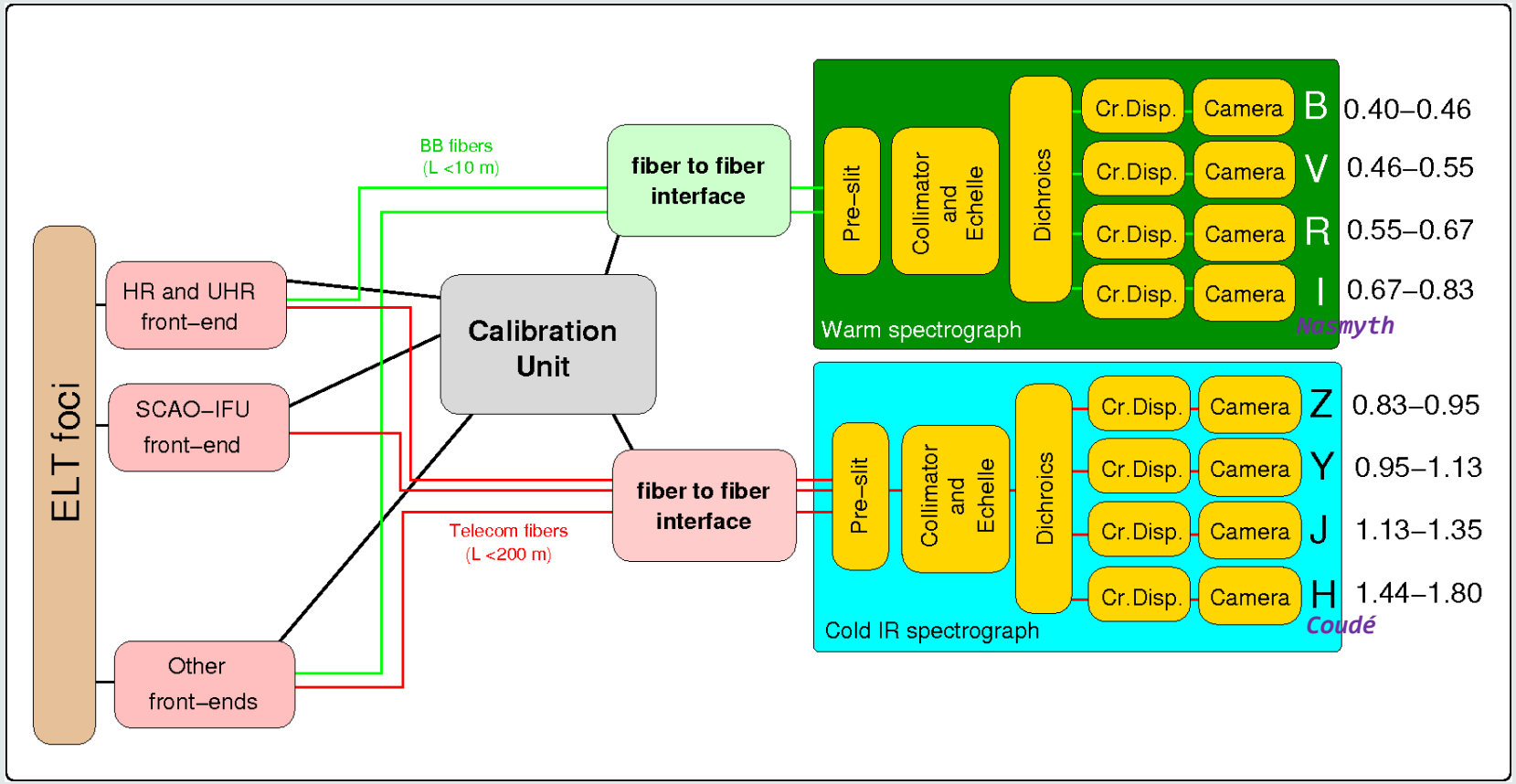
Phase A Top Level req

R-TLR-A.1 Spectral Resolution	The Instrument shall provide a **spectral resolution of at least 100000**	**1**
R-TLR-A.2 Spectral sampling	The spectrometers shall provide a target sampling of at least 2 pixels per resolution element. Goal of 3 pixel sampling is desirable.	1
R-TLR-A.3 Wavelength coverage	The instrument shall provide simultaneous and as complete as possible spectral coverage of the **500-1800 nm** wavelengths range.	1
R-TLR-A.4 Wavelength calibration accuracy and Instrument Stability	The instrument shall be able to achieve radial velocity accuracy better than **1m/s** between 500 and 1800nm	1
R-TLR-A.5 Spectral fidelity on spectra of bright sources	For a source of suitable (TBD) brightness it shall be possible to achieve **S/N > 1000 (TBC)** per resolution element in the 1D extracted spectrum from a single exposure using daytime calibrations	1
R-TLR-A.6 Sky Subtraction	For single science targets, a sky spectrum shall be recorded simultaneously with the spectrum of the science target.	1
R-TLR-A.7 Sky aperture	The instrument shall have seeing limited capability (no AO support is foreseen from the telescope)	1
R-TLR-A.8 Lifetime	The instrument shall have a lifetime of 10 yr (goal 20 yr)	1
R-TLR-A.9 Wavelength coverage +	The Instrument shall extend the spectral coverage (defined in R-TLR-A.3) at shorter wavelengths down to **400 nm (goal 370 nm)**	2
R-TLR-A.10 Integral field unit	The instrument shall provide an Integral field unit with variable scale up to 2 (TBC) spaxel sampling of the diffraction limit core of the PSF in the J band	3
R-TLR-A.11 Wavelength calibration accuracy and Instrument stability +	The instrument shall be able to achieve radial velocity accuracy better **than 0.02 m/s between 400 (goal 370) nm and 670 nm**	4

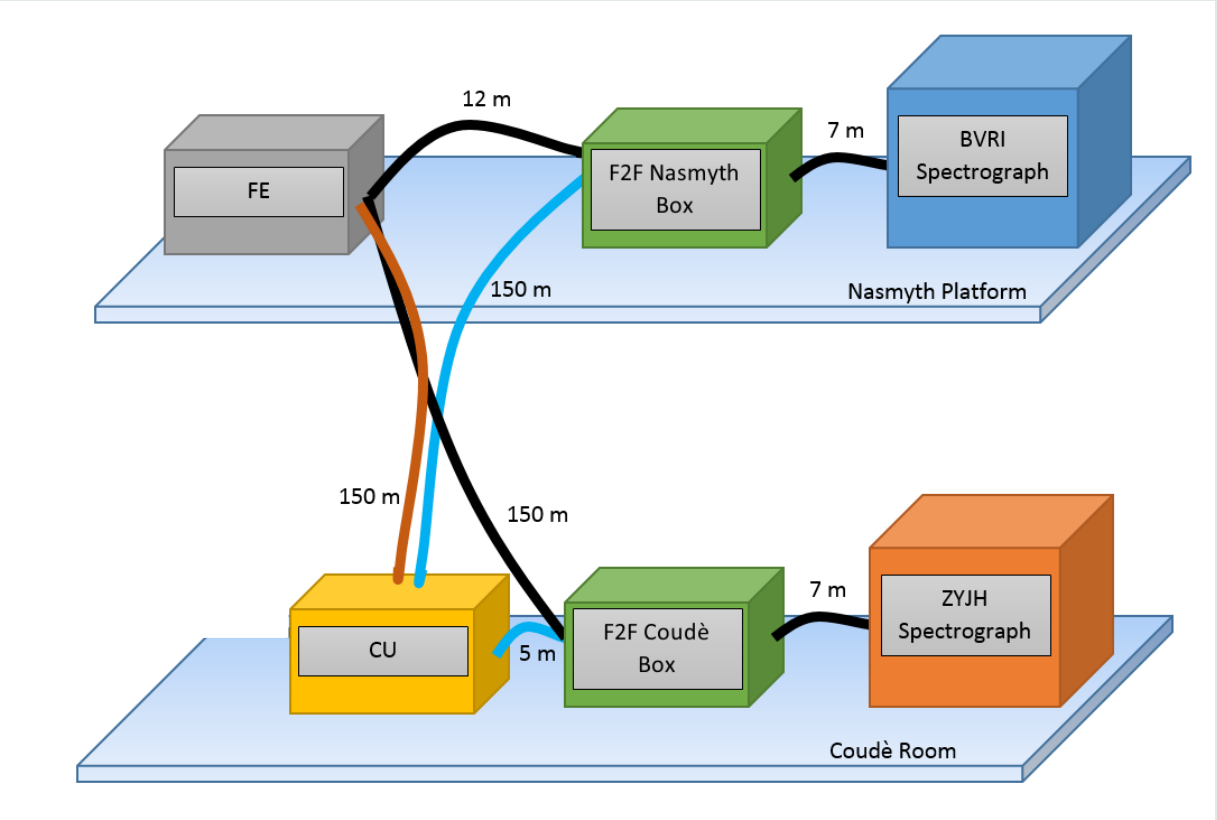
[1] Will be defined with simulations during Phase B
[2] Will be confirmed during Phase B
[3] Will be defined during Phase B

Cap cost 18 M€

Phase A Architecture



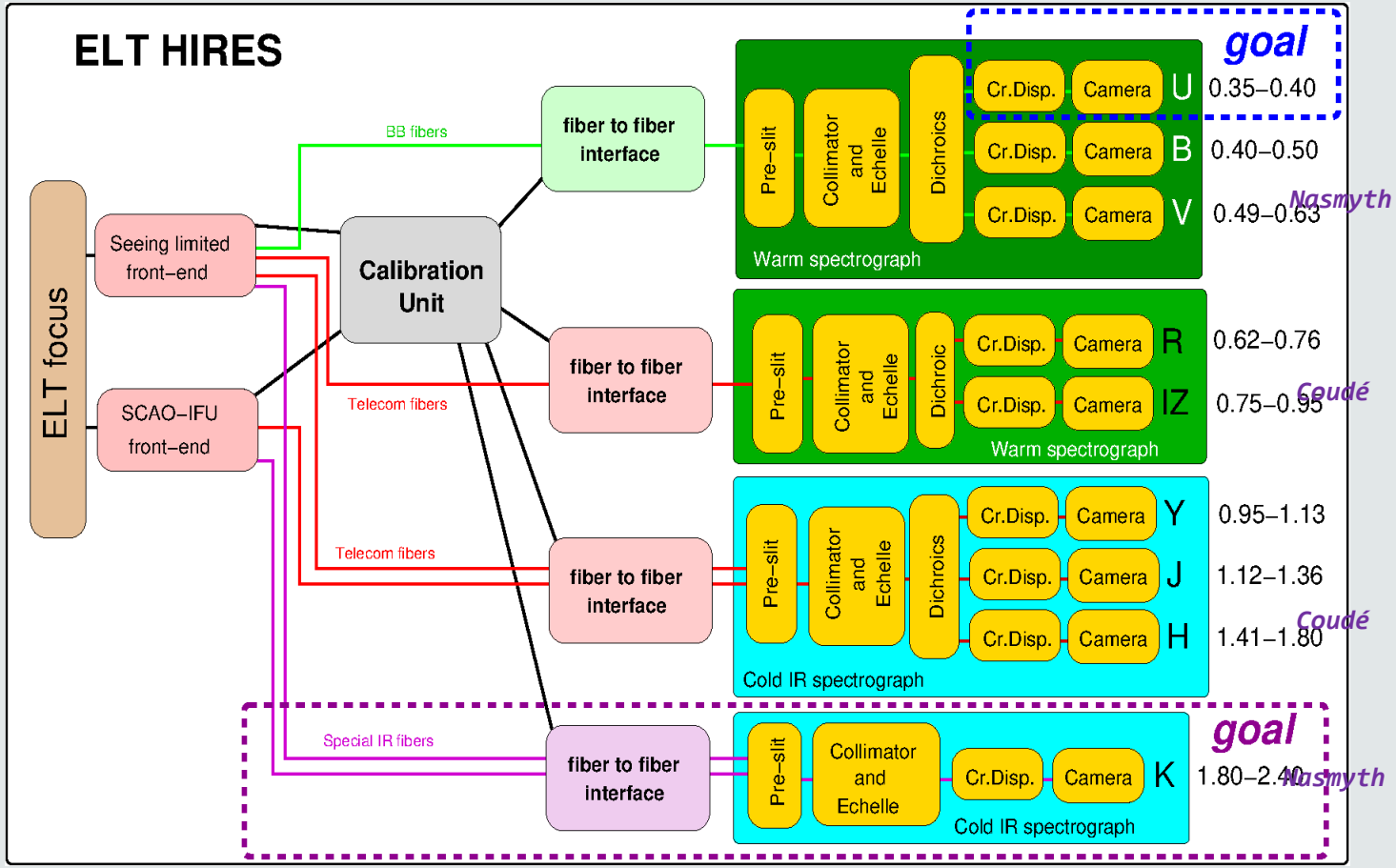
Overall deployment



Key parameters

+ 2 arcmin patrol field of view
+ Wavelength precision > 1m/s
+ Transmission > 7%
+ R=100 000
+ Sampling 4pix Vis, 2.5 pix IR
+ Spectral coverage 400 to 1800 (goal 350 to 2400 nm)
+ Contrast 1000 at 3l/D

pre phase B Architecture



AZA

- Scheme of the current baseline of the system
- Roles in the System Team
- SE Meetings
  + Tiger team at first (SE meeting slot with custom participants)
- Interactions, modeling
  + Cameo (with html interface to setup)
  + Excel (to exchange inputs ad update the model)
  + Ticketing (Jira/Confluence)
- Next events and Objectives

TRS, Requirements

[R-HIR- 20] D/A/I/T	The instrument shall have two observing modes: 1. Seeing-limited mode - 2. IFU mode
[R-HIR- 22a] D/A/I/T	The baseline design of HIRES covers the wavelength range specified in [R-HIR-40]. As a goal, the wavelength range will be extended to U-band and/or K-band.
[R-HIR- 255] D/A/-/T	**Exposure time** The instrument shall support individual exposure times between 1 seconds and 900 seconds (goal: 3600 seconds). The on-chip exposure time shall be known to 0.1 seconds, or 1% of the exposure time, whichever is smaller..
[R-HIR- 28] D/A/-/T	**Patrol field** The Instrument Field-of-View (area on sky) in seeing-limited mode shall allow picking- up two targets with a separation of up to 2 arcmin (goal: 5 arcmin) and recording their spectra simultaneously.
[R-HIR- 29] D/A/-/T	**Minimum separation** The minimum separation between two objects, which can be fed into the two fiber channels, shall be 15 arcsec (goal: 10 arcsec)
[R-HIR- 30] D/A/-/T	**Secondary guiding** HIRES shall stabilize the de-rotation and centering. The instrument shall allow tracking the object(s) with the pick-off arm(s). The tracking error shall be lower than 50mas rms in the seeing limited mode and lower than 2mas rms in the IFU mode over a timescale of 1hour.
[R-HIR- 32] D/A/-/T	**Wavelength precision (TLR-A.12 & TLR-A.20)** The Instrument shall achieve a precision in the wavelength calibration of better than 1 m/s RMS (goal: 0.1 m/s) averaged over the whole wavelength range specified in R-HIR-40.
[R-HIR- 33] D/A/-/T	**Stability of Wavelength Calibration Accuracy (TLR-A.12, TLR-A.17 & TLR-A.20)** The instrument shall achieve a short term (24 hours) stability of wavelength calibration accuracy of better than 1 m/s RMS over the wavelength range specified in R-HIR-40. As a goal, the instrument shall achieve a long-term stability of better than 0.02 m/s RMS over a 10 year period between 400 (goal: 350nm) and 670 nm.
[R-HIR- 34] D/A/-/T	**Transmission (TLR-A.8 & TLR-A.21)** The instrument shall have an average transmission >7% with a global minimum >4% (goal: >5%) at wavelengths longer than 400nm (goal: at wavelengths longer than 350nm). The transmission includes the detector quantum efficiency but excludes slit losses due to seeing.
[R-HIR- 35] D/A/-/T	**Limiting magnitude (TLR-A.13, TLR-A.21 & TLR-A.22)** The instrument shall provide a SNR=10 per spectral resolution element on the extracted spectrum at R=100,000 for a magnitude AB=20 (goal AB=21) in an exposure time Texp=1hr under median seeing conditions (as specified in AD5) at the reference wavelengths of V=550nm, I=850nm and J=1250nm (one for each spectrometer) . *Note, see [R-HIR-258] for a conversion to the photon flux at the instrument.*
[R-HIR- 36] D/A/-/T	**Spectral Resolution (TLR-A.1)** The instrument shall provide an average spectral resolution of R=100,000 with a variation within [-10%,+30 %] across the wavelength range.
[R-HIR- 40] D/A/-/T	**Spectral Wavelength Coverage (TLR-A.3, TLR-A.11 & TLR-A.19)** The instrument in seeing-limited mode shall provide a simultaneous spectral coverage from 400 nm to 1800 nm (goal: 350 nm to 2400 nm). Only one gap, less than 100 nm, centered between 1360 nm and 1410 nm shall be tolerated.
[R-HIR- 259] D/A/-/T	**Seeing-limited image quality** The instrument shall deliver under the best seeing conditions (seeing<0.3arcsec) an image quality of a point source better than 85% (goal: 95%) encircled energy within 0.4 arcsec radius over the full wavelength range specified in [R-HIR-40].
[R-HIR- 41] D/A/-/T	**Aperture and Field-of-View (TLR-A.6, TLR-A.7 & TLR-A.10)** The instrument in seeing-limited mode shall have at least two sub-FoV, which allow the simultaneous observation of two science targets or one science target and a sky background. The full spectrograph FoV (i.e. the full slit) projected on the sky shall cover more than 1 square-arcsec (goal: 2 square-arcsec).
[R-HIR- 42] D/A/-/T	**Spectral Wavelength Coverage (TLR-A.15 & TLR-A.19)** The instrument in IFU mode shall provide a simultaneous spectral coverage from 980 nm to 1800 nm (goal: *600 nm to 2400 nm*). Only one gap, less than 100 nm, centered between 1360 nm and 1410 nm shall be tolerated.

Parameters of the current design

Seeing limited observing modes

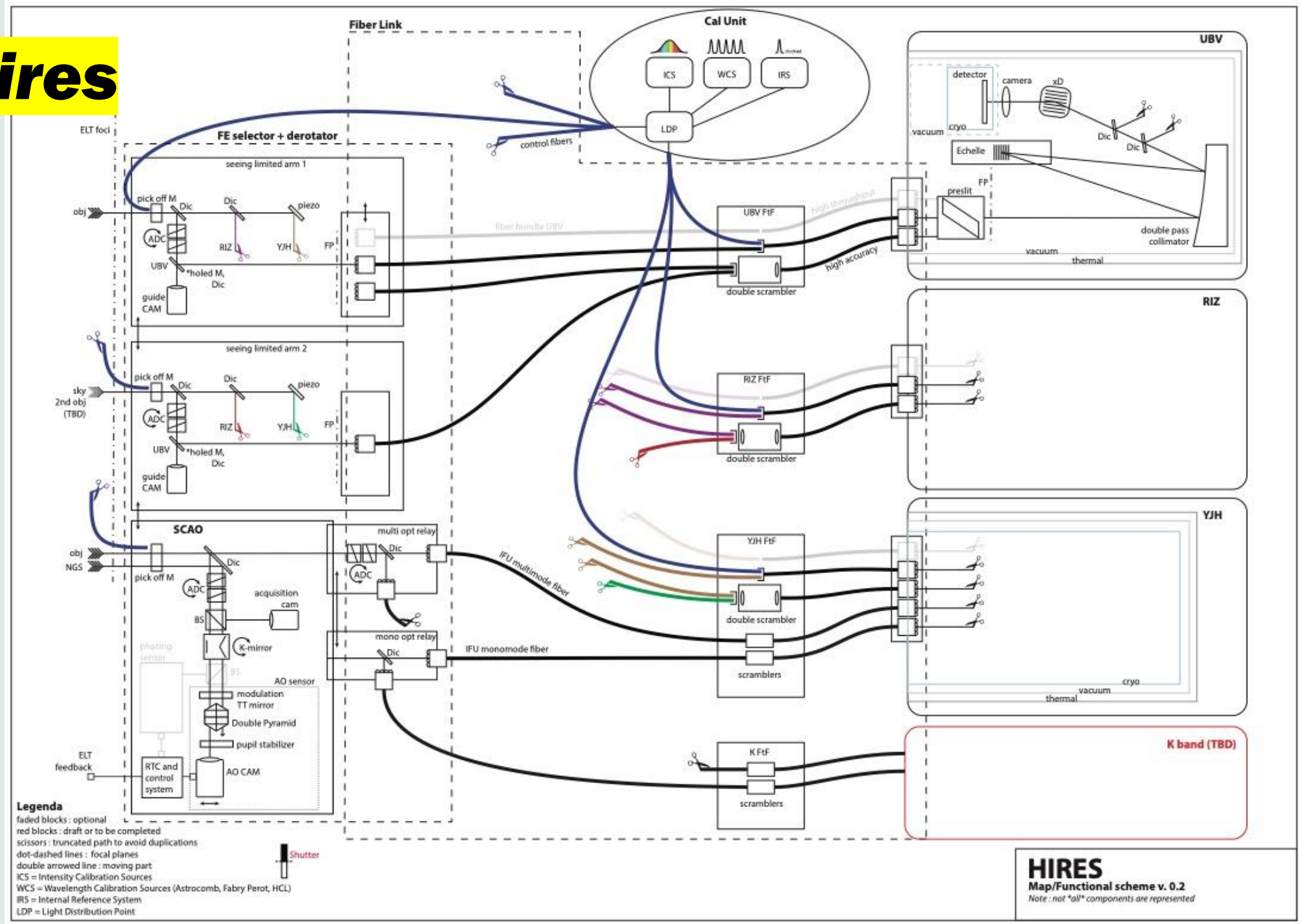
Parameter	value	Options and comments
Resolving power	100 000	Could be increased to 130,000 for RIZ & (U)BV
Spectral sampling	2.7 (YJH); >4 (U-Z)	pixels
Simultaneous lambda coverage	400-1800 nm	Optional extension to U (350-400 nm) and/or K (1900-2400 nm).
Apertures	2 x D=0.75”	Obj. + sky; ~5% of slit for simultaneous calib.
Baseline observing mode	Optimized for spectral fidelity on bright objects	Each spectrometer aperture is uniformly illuminated regardless of input PSF. Each spectral res. element is sampled by many (~200) pixels; detector noise dominates for faint objects
Optional observing mode	Optimized for faint objects	IFU-like illumination of spectrometer slit, to take advantage of telescope PSF. Entrance apertures mapped on 0.125” spaxels. *Important: SCAO correction is not available for this observing mode.*

IFU Observing Modes (no R&D WPs)

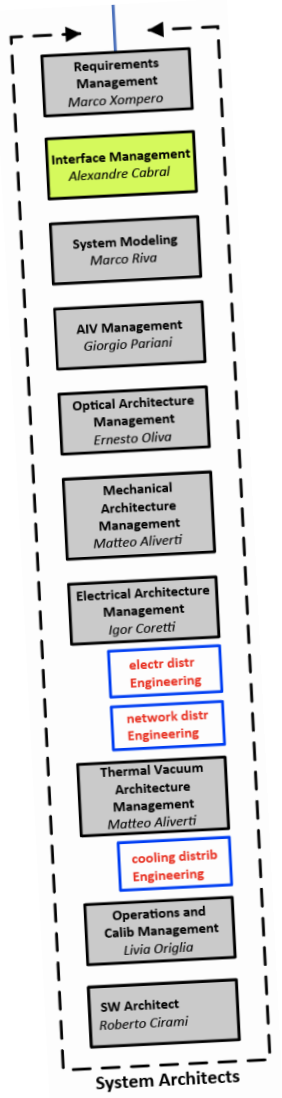
Parameter	value	Options and comments
Resolving power	100 000	Same as seeing limited
Spectral sampling	2.7	Pixels
Simultaneous lambda coverage	950-1800 nm	Only the YJH spectrometer; optional extension to K-band (1900-2400 nm)
# of spaxels	61	Organized in a hexagonal matrix
Spaxel scale	Up to five scales, e.g., 5, 10, 20, 50, 100 mas/spaxel	Scales always available for observation. Option with single scale (mono-mode IFU) proposed by SCAO-IFU WG.
AO correction	SCAO	SCAO loop can be closed on the scientific target (on-axis) or on a nearby object, maximum off-axis distance is 3”

Map of Hires

- Not a functional diagram or a product tree but a visual map to understand the overall system
- Specific diagrams will be generated by MBSE software



System Engineering Team: Architects



- Refer to the sheets for tasks and objectives

1_WP_Requirements Management.docx — Apri con Microsoft Word

Project: HIRES	**Phase: B**	**WP ID: TBD**
WP Title: Requirements Management		
WP Objective: – Support the System Engineer in the definition of the system requirements flow down – Manage and control the flow down of system requirements to subsystem requirements – Supply the model manager with requirements input – Compile the subsystem requirements document with inputs from other architects		
WP Manager: Marco Xompero **Deputy:** -		**Institute:** OAA **Deputy institute:** -
Other contributors (with affiliation): **Alessio Zanutta** (INAF-OABr), **Matteo Genoni** (INAF-OABr), **Matteo Aliverti** (INAF-OABr), **Giorgio Pariani** (INAF-OABr), **Igor Coretti** (INAF-OATs), **Ernesto Oliva** (INAF-OAA), **Marco Riva** (INAF-OABr)		
Duration: T0 + 24 m		
WP Required Resources		
Total WP: 0,4 (already included in SE work package) 0,2 FTE/yr (already included in SE work package)		
WP Costs		
Included in SE WP		
Required Inputs		
– Technical Specifications – ESO Applicable Documents – ...		
Interfaces		
SE, SWSE (software-SE), s-SE (subsystem-Engineers), other Architects		
Expected Outputs/Deliverables		
– Subsystem requirements datapack – Requirement tracing matrixes – ...		

Difference btw sSEs and Architects.

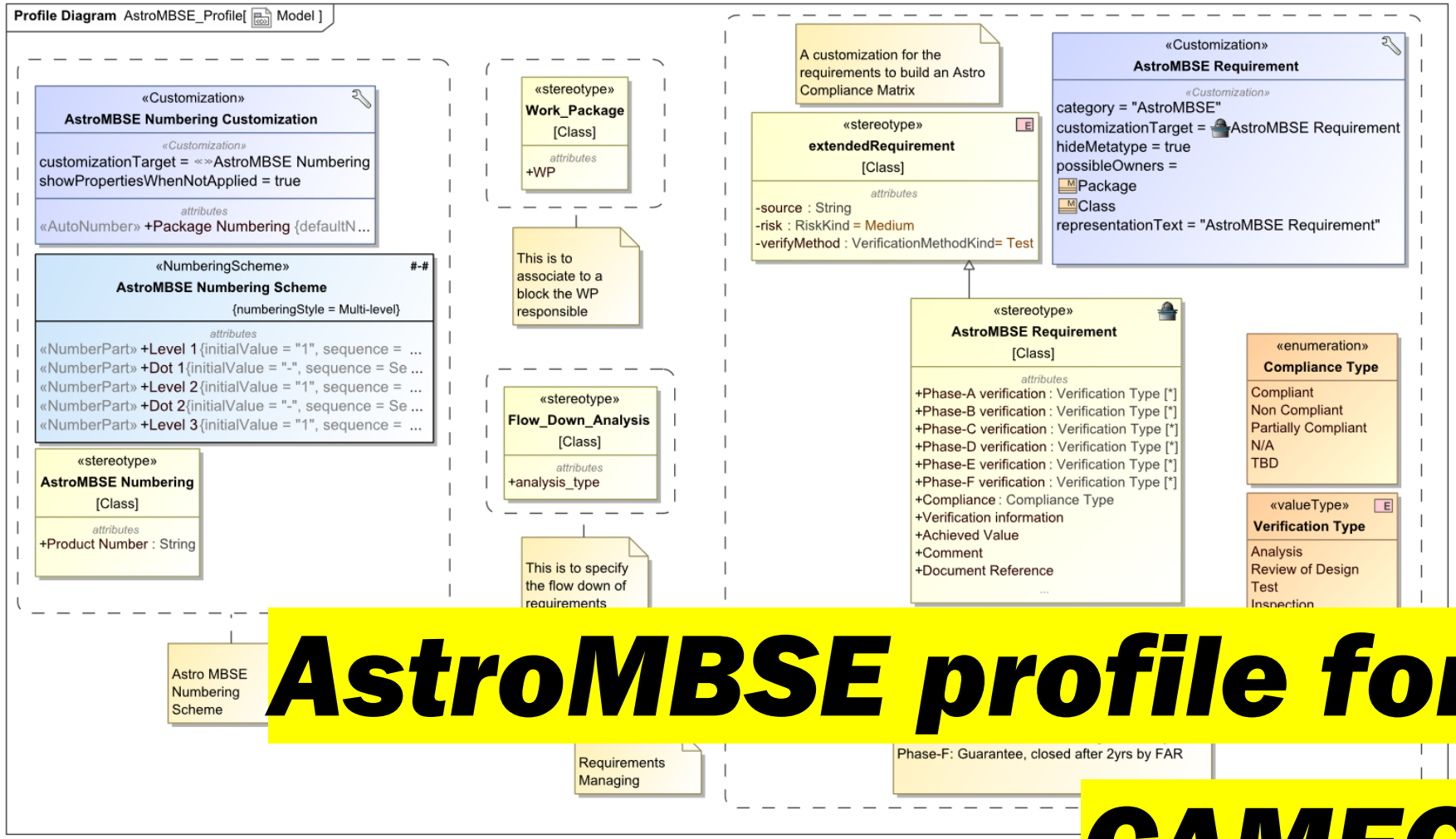
Arch.s Present themeseves

SubSEs

SubSys. Eng.s *[your presence at the SE meetings is very important]*	Manuel Abreu (FE SE)
	Andrea Tozzi (FL SE)
	Michael Weber (UBV SE)
	Bruno Chazelas (RIZ SE)
	Mike Macintosh (YJH SE)
	Enrico Pinna (SCAO-IFU SE)
	Philip Huke (CU SE)
	Roberto Cirami (SW SE)
Architects *[you are always welcome to join the SE meeting, but you will be formally invited when a specific discussion in the agenda requires your expertise]*	Livia Origlia (Op.&Cal. Arch.)
	Tino Oliva (Opt. Arch.)
	Marco Xompero (Req. Arch.)
	Alexandre Cabral (Interf. Arch.)
	Matteo Aliverti (Mec. Arch., Term. Arch.)
	Igor Coretti (Ele. Arch.)
	Giorgio Pariani (AIV Arch.)
	Marco Riva (Model Arch.)

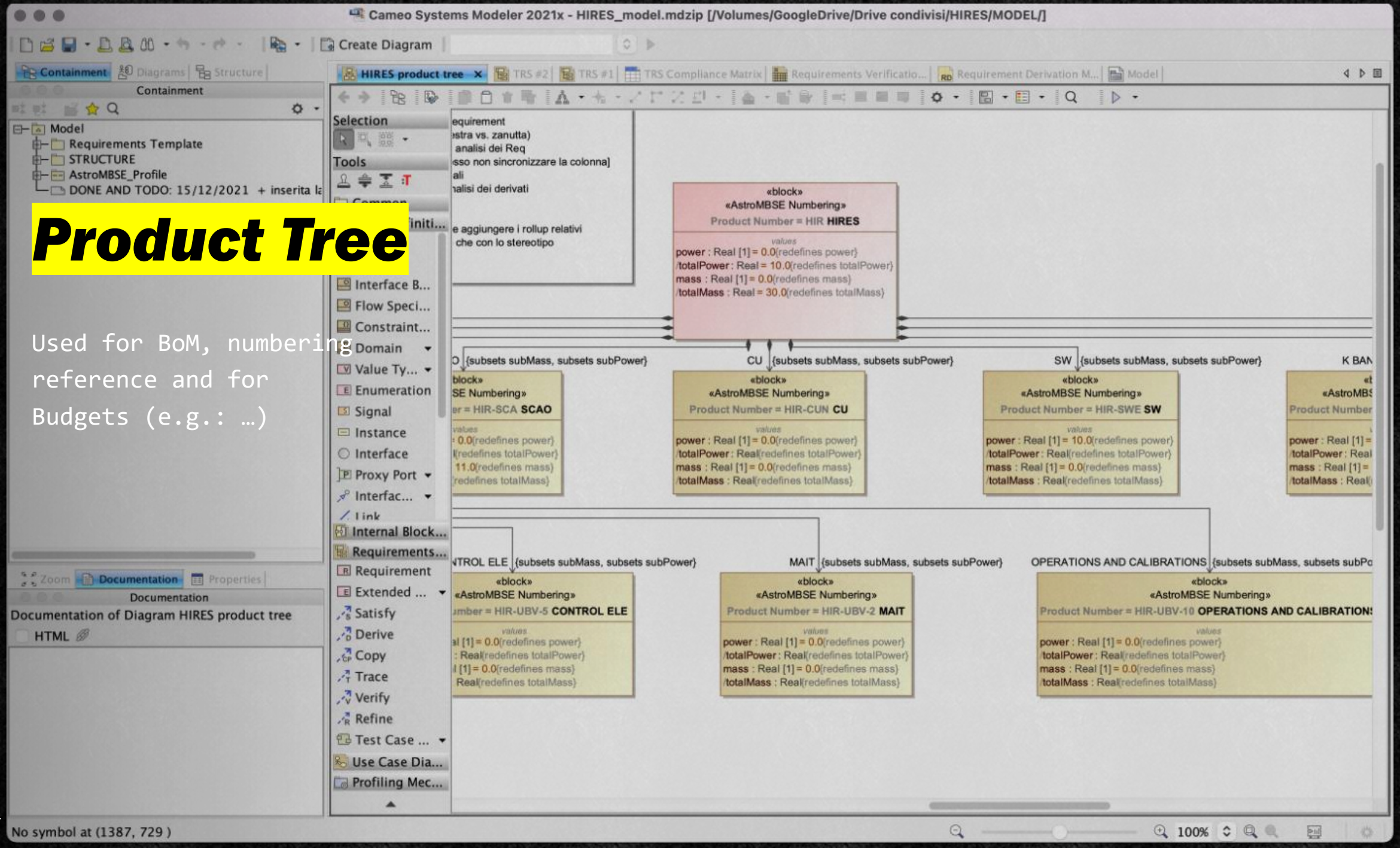
Tiger Teams

- For initial Tradeoffs and important activities
- Themes:
  + Monomode IFU, AO
  + Impact of K band (cryo stuff in IFU?)
  + Consequences on the Calibration Unit
  + AoB
- Timeslot SE biweekly (odd weeks) – next 21 gen 2022 @ 14:00 CET



AstroMBSE profile for CAMEO

Customization for Astronomical Instrument Model Managing



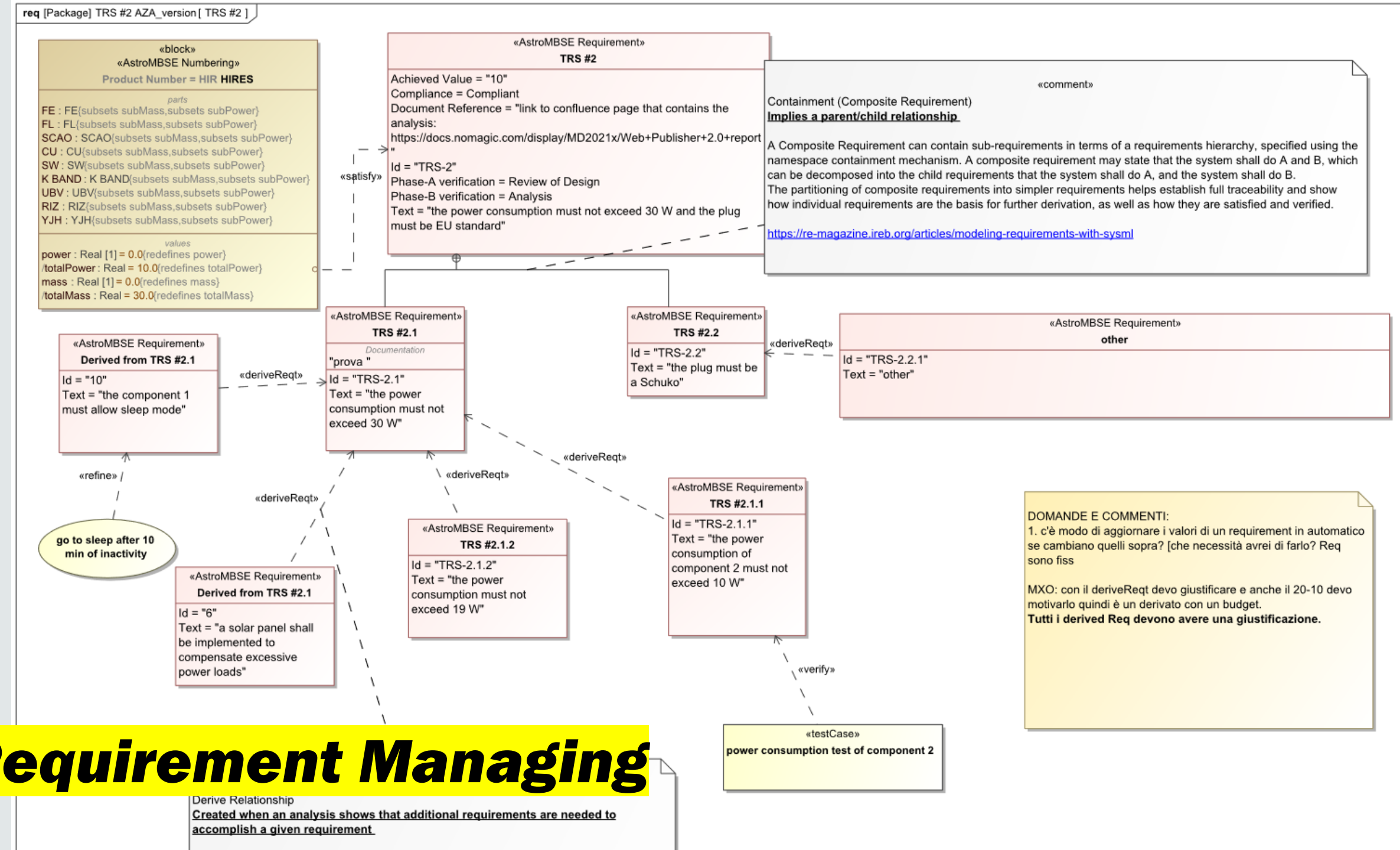
Product Tree

Used for BoM, numbering reference and for Budgets (e.g.: …)

Requirement Managing

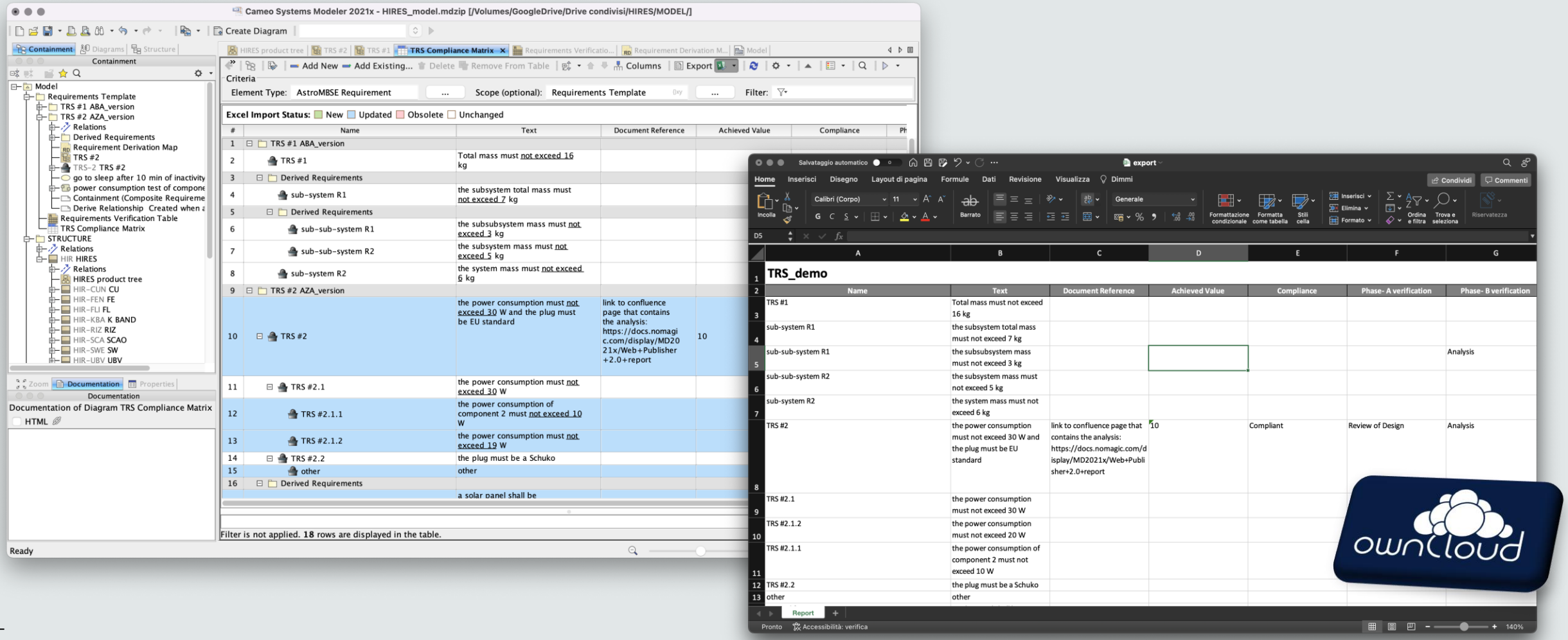
Example, not HIRES

#	Name	Text	Property	Value	Margin
1	TRS #1 ABA_version				
2	Derived Requirements				
3	Derived Requirements				
4	TRS-1.1.1 sub-sub-system R1	the subsubsystem mass must not exceed 3 kg			
5	TRS-1.1.2 sub-sub-system R2	the subsystem mass must not exceed 5 kg			
6	TRS-1.1 sub-system R1	the subsystem total mass must not exceed 7 kg			
7	TRS-1.2 sub-system R2	the system mass must not exceed 6 kg			
8	TRS-1 TRS #1	Total mass must not exceed 16 kg	totalMass : Real	30	-14
9	TRS #2 AZA_version				
10	Derived Requirements				
11	6 Derived from TRS #2.1	a solar panel shall be implemented to compensate excessive power loads			
12	10 Derived from TRS #2.1	the component 1 must allow sleep mode			
13	TRS-2 TRS #2	the power consumption must not exceed 30 W and the plug must be EU standard	totalPower : Real	10	20
14	TRS-2.1 TRS #2.1	the power consumption must not exceed 30 W			
15	TRS-2.1.1 TRS #2.1.1	the power consumption of component 2 must not exceed 10 W			
16	TRS-2.1.2 TRS #2.1.2	the power consumption must not exceed 19 W			
17	TRS-2.2 TRS #2.2	the plug must be a Schuko			
18	TRS-2.2.1 other	other			


req [Package] TRS #2 AZA_version [TRS #2]
«block»
«AstroMBSE Numbering»
Product Number = HIR HIRES
parts
FE : FE{subsets subMass,subsets subPower}
FL : FL{subsets subMass,subsets subPower}
SCAO : SCAO{subsets subMass,subsets subPower}
CU : CU{subsets subMass,subsets subPower}
SW : SW{subsets subMass,subsets subPower}
K BAND : K BAND{subsets subMass,subsets subPower}
UBV : UBV{subsets subMass,subsets subPower}
RIZ : RIZ{subsets subMass,subsets subPower}
YJH : YJH{subsets subMass,subsets subPower}
values
power : Real [1] = 0.0{redefines power}
/totalPower : Real = 10.0{redefines totalPower}
mass : Real [1] = 0.0{redefines mass}
/totalMass : Real = 30.0{redefines totalMass}
«satisfy»
«AstroMBSE Requirement»
TRS #2
Achieved Value = "10"
Compliance = Compliant
Document Reference = "link to confluence page that contains the analysis:
https://docs.nomagic.com/display/MD2021x/Web+Publisher+2.0+report
"
Id = "TRS-2"
Phase-A verification = Review of Design
Phase-B verification = Analysis
Text = "the power consumption must not exceed 30 W and the plug must be EU standard"
«comment»
Containment (Composite Requirement)
Implies a parent/child relationship
A Composite Requirement can contain sub-requirements in terms of a requirements hierarchy, specified using the namespace containment mechanism. A composite requirement may state that the system shall do A and B, which can be decomposed into the child requirements that the system shall do A, and the system shall do B.
The partitioning of composite requirements into simpler requirements helps establish full traceability and show how individual requirements are the basis for further derivation, as well as how they are satisfied and verified.
https://re-magazine.ireb.org/articles/modeling-requirements-with-sysml
«AstroMBSE Requirement»
TRS #2.1
Documentation
"prova "
Id = "TRS-2.1"
Text = "the power consumption must not exceed 30 W"
«AstroMBSE Requirement»
TRS #2.2
Id = "TRS-2.2"
Text = "the plug must be a Schuko"
«deriveReqt»
«AstroMBSE Requirement»
other
Id = "TRS-2.2.1"
Text = "other"
«AstroMBSE Requirement»
Derived from TRS #2.1
Id = "10"
Text = "the component 1 must allow sleep mode"
«deriveReqt»
«refine»
go to sleep after 10 min of inactivity
«deriveReqt»
«deriveReqt»
«deriveReqt»
«AstroMBSE Requirement»
TRS #2.1.1
Id = "TRS-2.1.1"
Text = "the power consumption of component 2 must not exceed 10 W"
«AstroMBSE Requirement»
TRS #2.1.2
Id = "TRS-2.1.2"
Text = "the power consumption must not exceed 19 W"
«AstroMBSE Requirement»
Derived from TRS #2.1
Id = "6"
Text = "a solar panel shall be implemented to compensate excessive power loads"
«verify»
«testCase»
power consumption test of component 2
DOMANDE E COMMENTI:
1. c'è modo di aggiornare i valori di un requirement in automatico se cambiano quelli sopra? [che necessità avrei di farlo? Req sono fiss
MXO: con il deriveReqt devo giustificare e anche il 20-10 devo motivarlo quindi è un derivato con un budget.
Tutti i derived Req devono avere una giustificazione.
Derive Relationship
Created when an analysis shows that additional requirements are needed to accomplish a given requirement
Requirement Managing

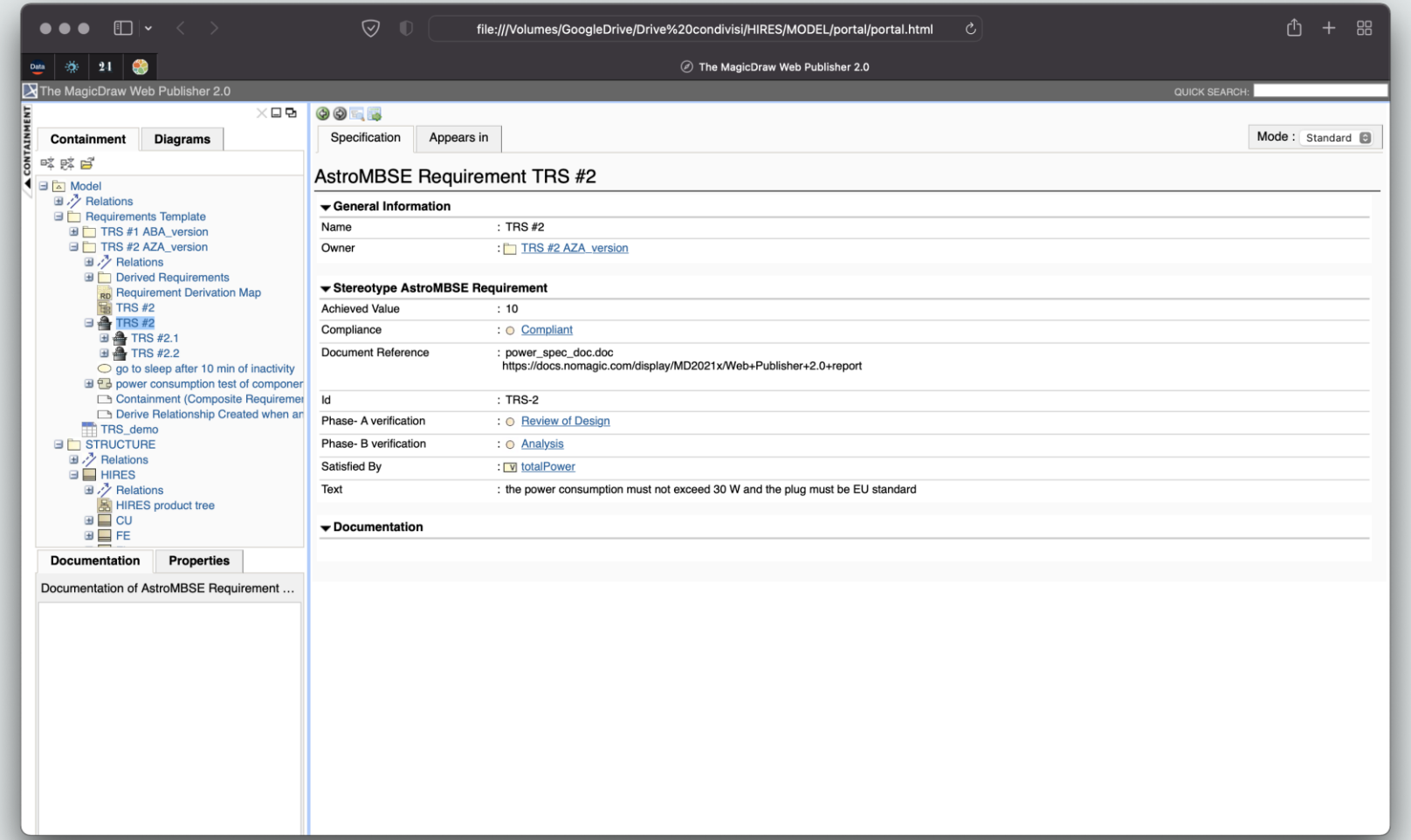
CAMEO export-inport

Via excel sheets stored in owncloud

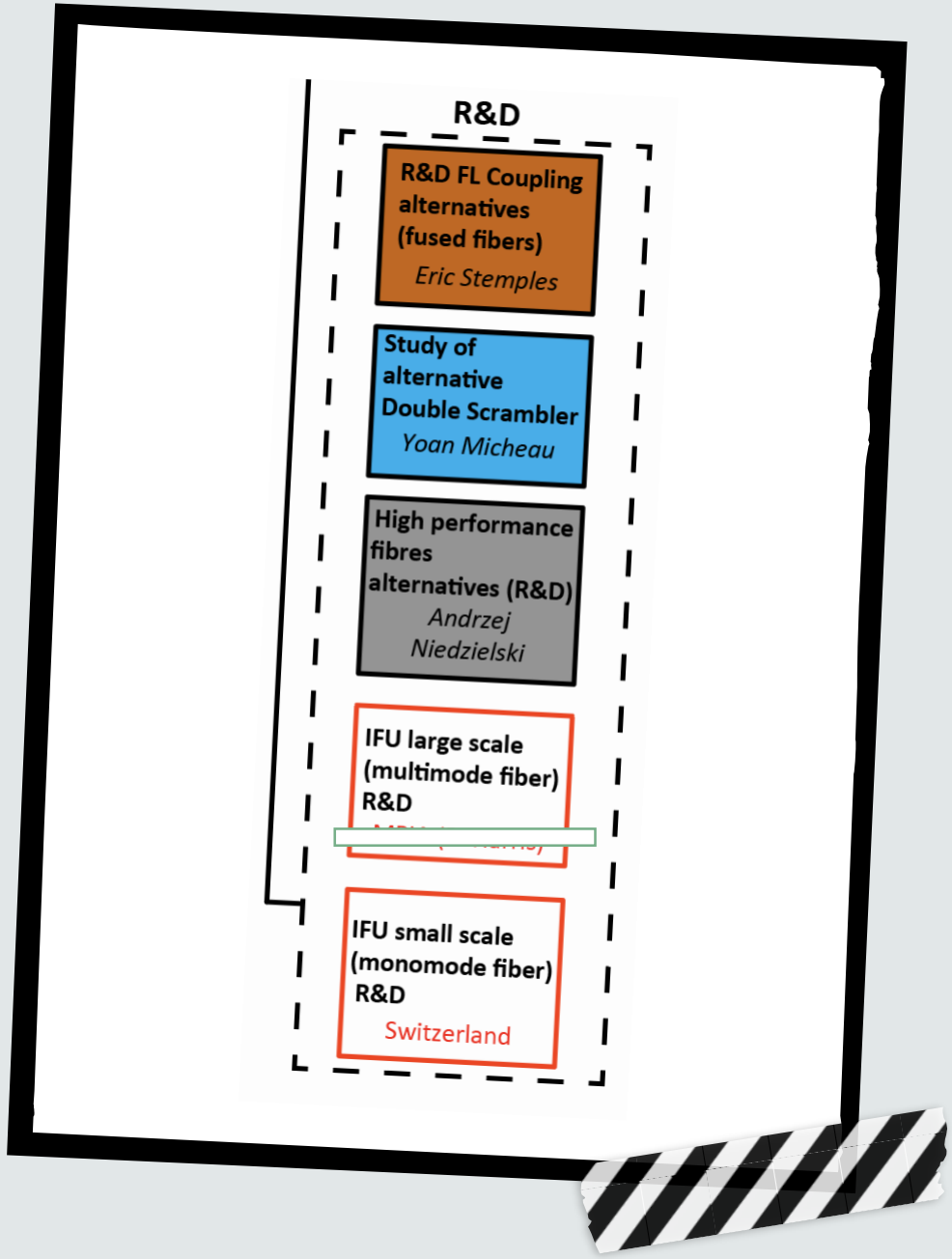


HTML interface

- As reference for:
  - + Requirements
  - + Structure, PT, numbering, BoM
  - + Interfaces
  - + Functions, Actions
  - + Budgets



Horizon Europe Call for instrument development funding (aka OPTICON22)



Next Flow of Events & Objectives

- test of the communication lines and interactions (SE team with subsystems)
  + Collaborative tools implementation, usage directions
- Consolidation of the Architecture (from Tech Specs and Science Cases to:)
  + Critical items identification
  + subsystem feasibility assessments
  + PT, numbering
  + Interfaces definition between subsystems
  + subsystem Req.s flow-down
- System Design (definition of the System from the Architecture)
  + Build the Drawings basing on the Architectural scheme