

ALESSIO ZANUTTA

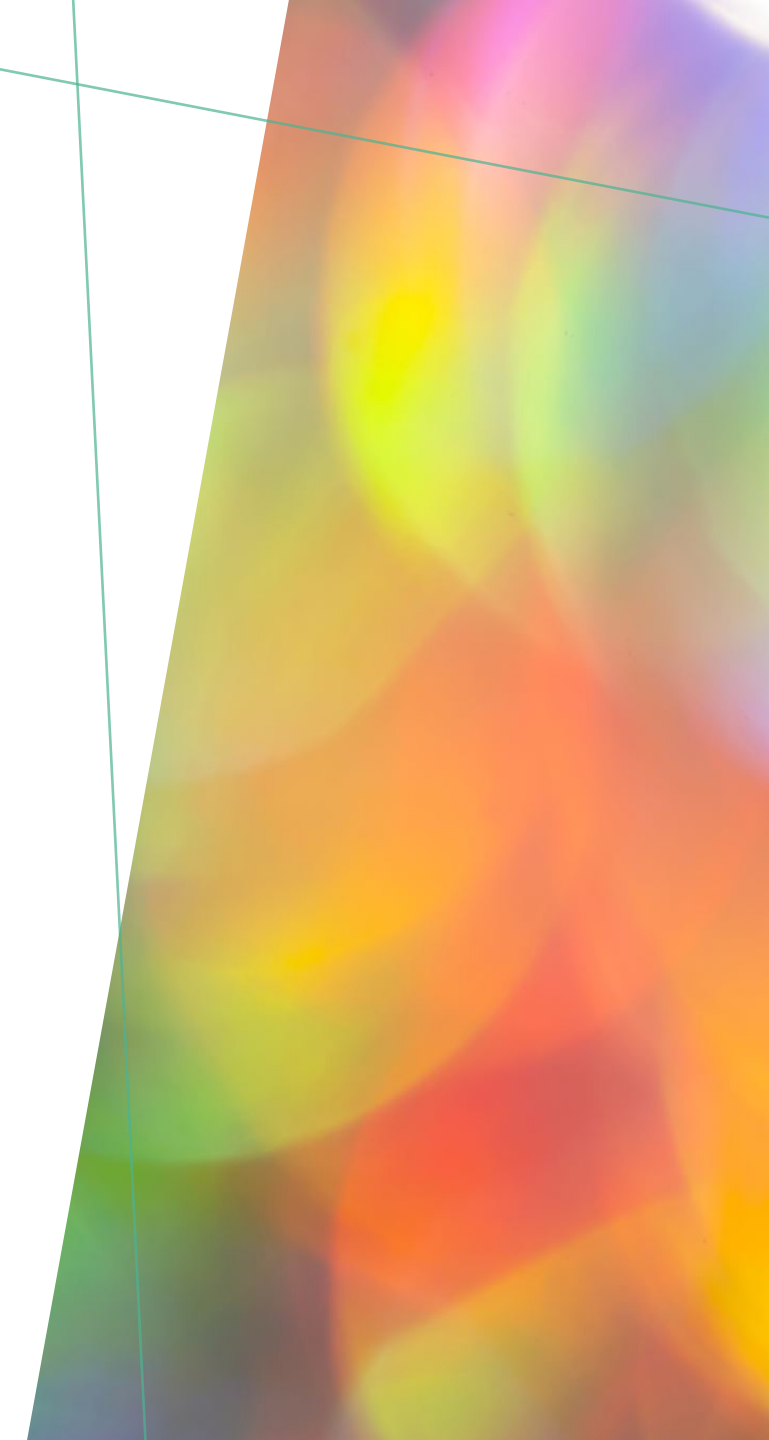
INAF – OSSERVATORIO ASTRONOMICO DI BRERA-
MERATE

MODEL BASED SYSTEM ENGINEERING

FORUM DELLA RICERCA SPERIMENTALE E TECNOLOGICA IN INAF

22-24 JUN 2022

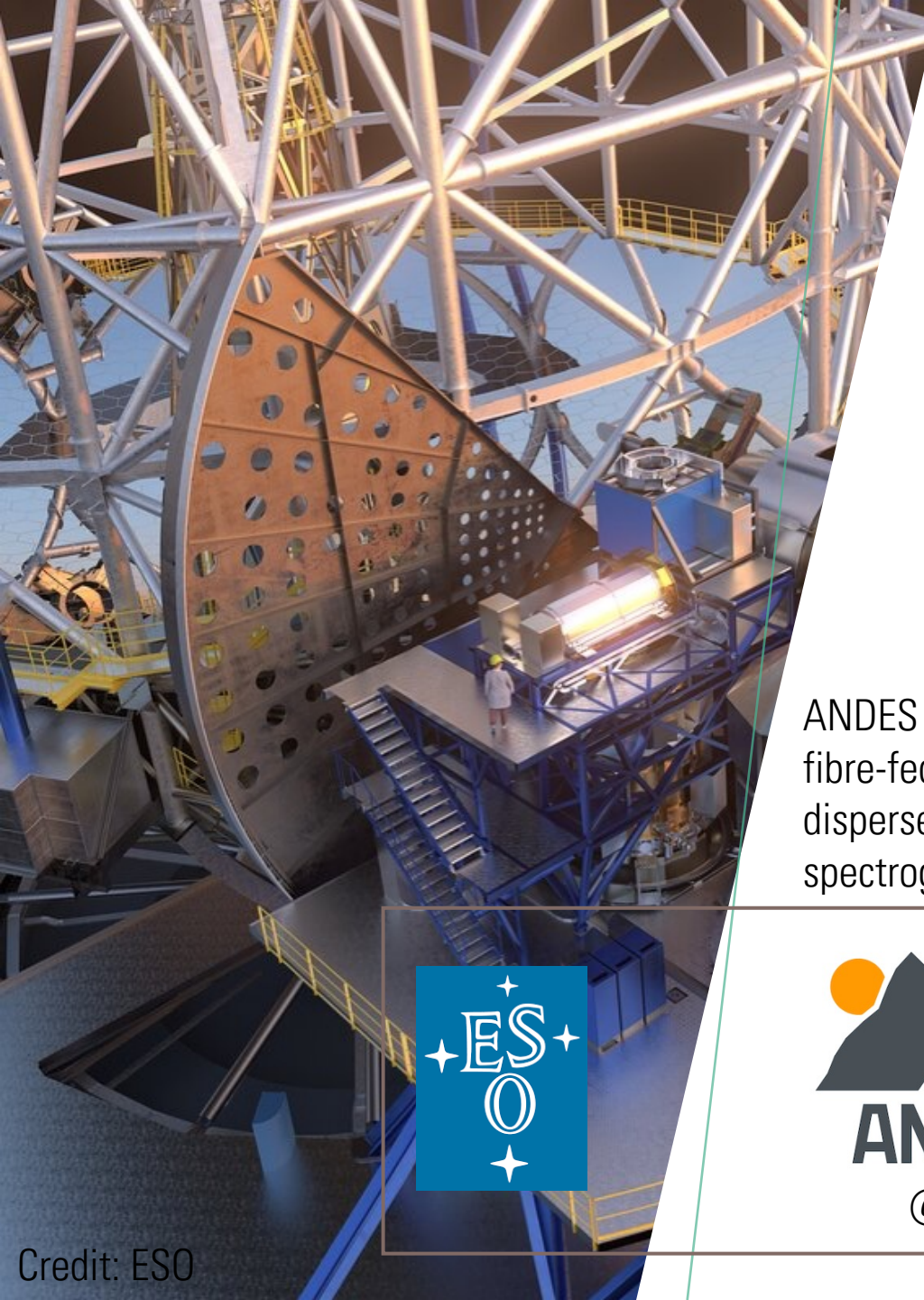
AREA RICERCA BOLOGNA



VANTAGGI DELL'MBSE NELL'INTERO CICLO DI VITA DELLA STRUMENTAZIONE

- La crescente **complessità** degli strumenti determina l'esigenza di progettarli, realizzarli e gestirli attraverso la collaborazione tra **più discipline ingegneristiche**. La progettazione di un sistema mediante l'uso di modelli ne consente la visualizzazione e simulazione sin dalle **fasi iniziali**, migliorando il coinvolgimento delle parti interessate.
- Il System Engineering basato su modelli, o MBSE, consente processi innovativi e collaborativi di progettazione e manutenzione di strumentazione. Inoltre, aiuta i consorzi a ottimizzare l'impiego delle risorse garantendo conformità ai *requirements* anche attraverso *tool* di simulazione.





PROGETTI, RUOLI SE & SQUADRA @ OABR

- Alessio Zanutta
- Marco Riva
- Matteo Genoni

Dall'esperienza di



si è capita la necessità di un nuovo approccio per far fronte alla complessità degli strumenti di nuova generazione. Si è gettato il seme per l'MBSE



ANDES is a modular fibre-fed cross dispersed echelle spectrograph

MAORY is a multi-conjugate adaptive optics system

CUBES is a U-Band Cassegrain spectrograph (R ca. 20k)

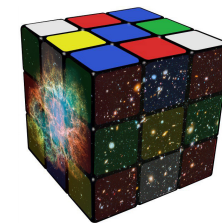


ANDES

@ ELT



@ ELT



CUBES

@ VLT

CAMEO SYSTEMS MODELER™

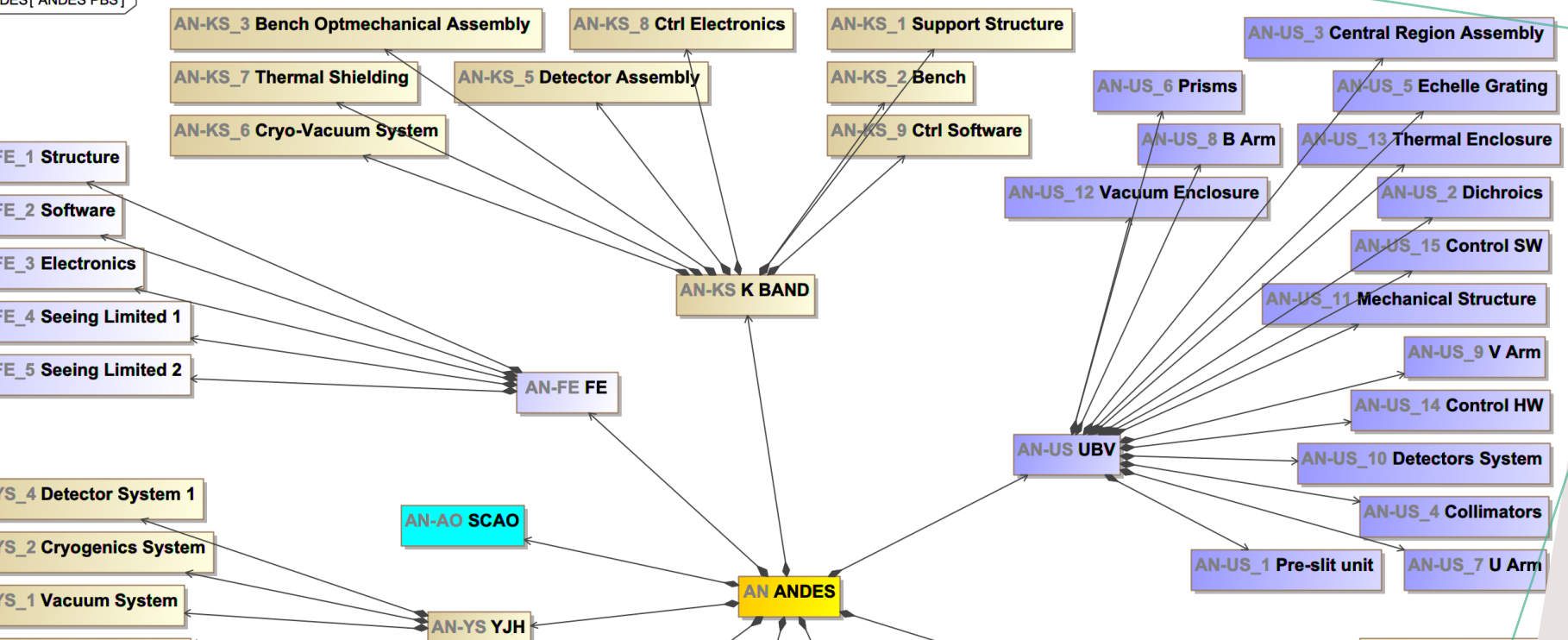
APPROCCIO MBSE CON CAMEO SYSTEM MODELER

The screenshot displays the Cameo Systems Modeler 2021x interface. The left sidebar shows a project tree with folders like 'ANDES Interfaces', 'Requirements', and 'STRUCTURE'. The main window shows a table of requirements with columns for '#', 'Id', 'Text', 'Refined By', and 'Comment'. The table contains three rows of requirements, with the first row being expanded to show a list of refined requirements.

#	Id	Text	Refined By	Comment
1	[R-AND-167]	ANDES shall comply with the delivery and packaging requirements defined in Sec. 11 of AD2. If a sub-system will not fit into a standard ISO shipping container (ref. AD2 §11.2; INFO-INS-706), then a separate shipping arrangements for this shall be made as part of the instrument shipping plan.	<ul style="list-style-type: none"> AN-AO-03-00 SCAO_ AN-CU-04-00 CU_WF AN-RS-04-00 RIZ_WF AN-KS-04-00 K-BAN AN-FL-03-00 FL_WP AN-FE-03-00 FE_WP AN-SE-08-00 AIV AN-SI-01-00 Instrum AN-SW-04-00 SW_WF AN-US-04-00 UBV_W AN-YS-04-00 YJH_WI 	
2	[R-AND-165]	ANDES shall comply with the common requirements AD2 (in particular Sec. 10).	<ul style="list-style-type: none"> AN-SE-02-00 Requir AN-SE-08-00 AIV AN-SW-04-00 SW_WF AN-US-04-00 UBV_W AN-YS-04-00 YJH_WI AN-AO-03-00 SCAO_ AN-CU-04-00 CU_WF AN-FE-03-00 FE_WP AN-FL-03-00 FL_WP AN-KS-04-00 K-BAN AN-RS-04-00 RIZ_WF 	
3	[R-AND-163]	Lifetime (TLR-A.9) ANDES shall have a <u>minimum lifetime of 15yrs</u> (goal: 20yrs)	<ul style="list-style-type: none"> AN-SE-02-00 Requir AN-RS-04-00 RIZ_WF AN-FL-03-00 FL_WP AN-AO-03-00 SCAO_ AN-FE-03-00 FE_WP AN-KS-04-00 K-BAN AN-CU-04-00 CU_WF AN-YS-04-00 YJH_WI AN-SW-04-00 SW_WF AN-US-04-00 UBV_W AN-SE-02-00 Requir 	

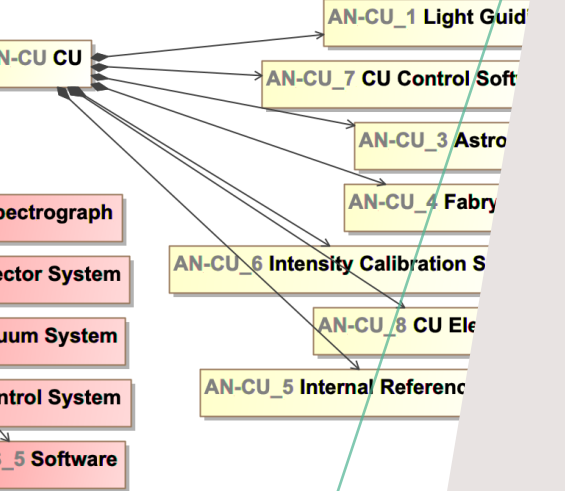
Filter is applied on 36 of 83 rows.

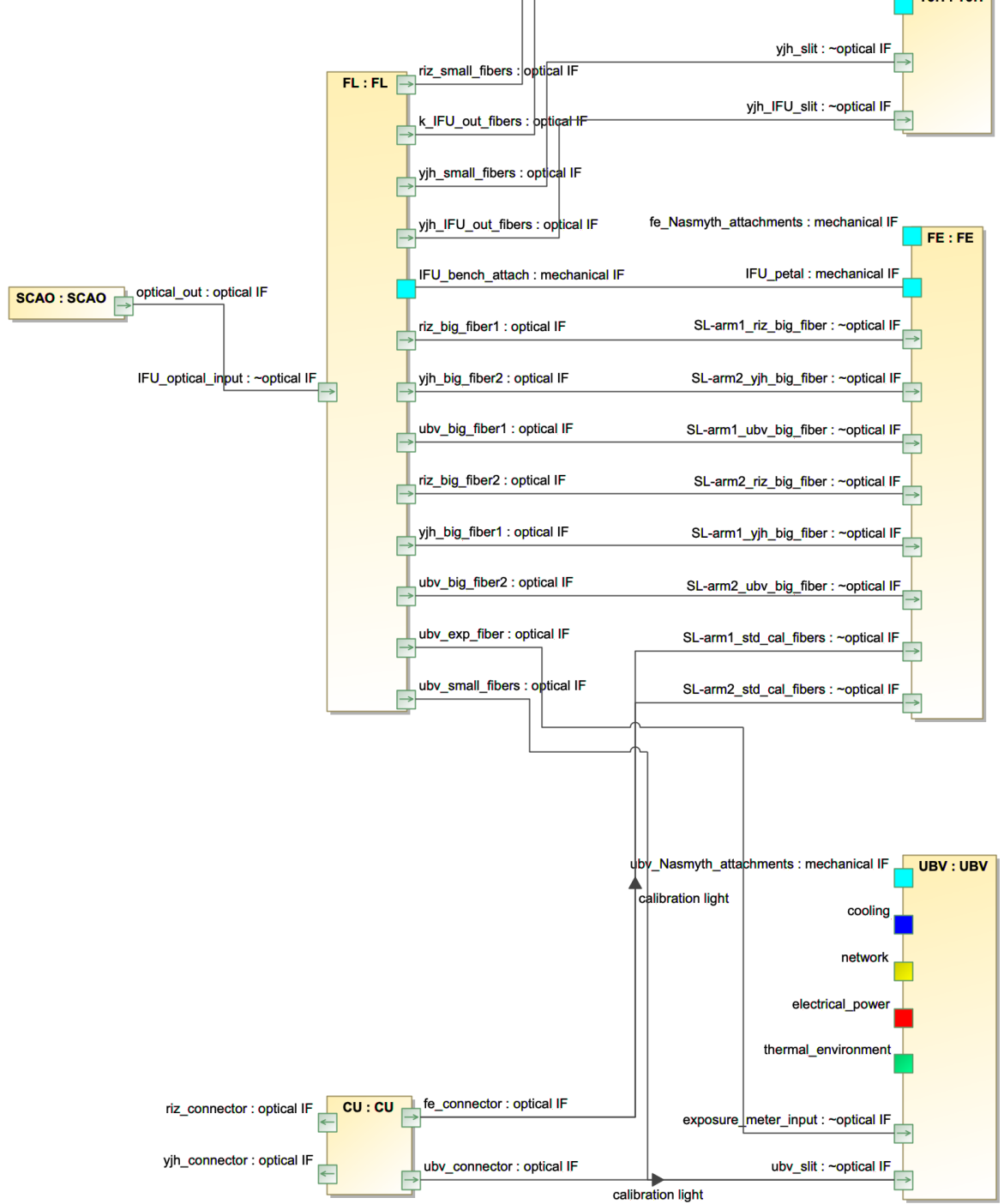
- Linguaggio SysML
- Eseguire analisi ingegneristiche per prendere decisioni di design
- Verifica dei requirement e use case
- Tracking del progresso e dei cambiamenti nel progetto
- Possibilità di nuove funzionalità attraverso profili custom e script



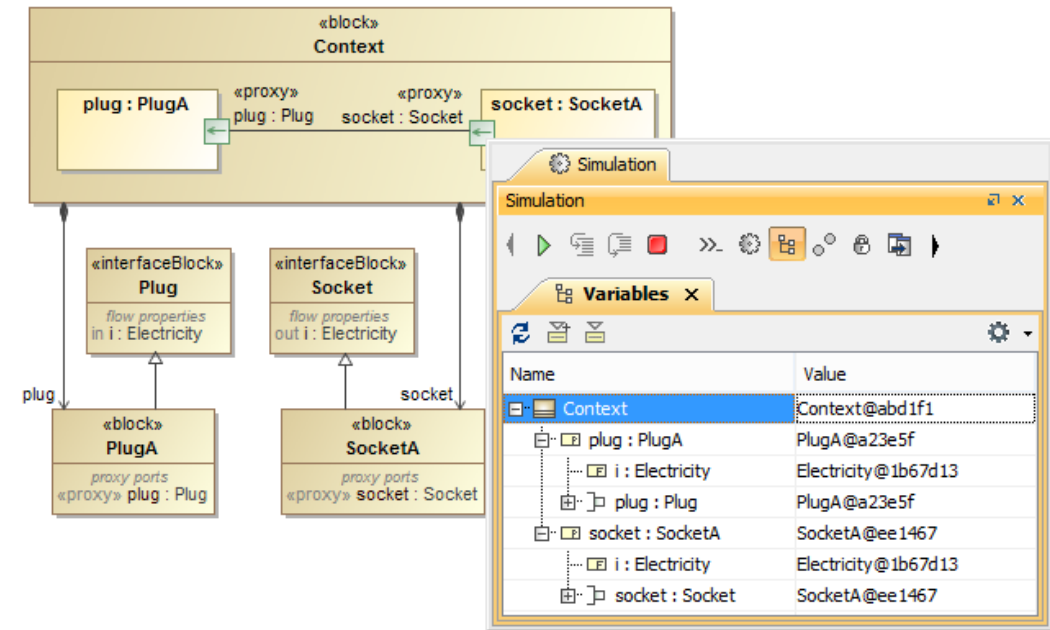
PRODUCT BREAKDOWN
STRUCTURE
&
WORK BREAKDOWN
STRUCTURE

#	Model Number	Name	Owner	Documentation	WP
1	AN-KS	K BAND	AN ANDES		KS-00-00
2	AN-KS_1	Support Structure	AN-KS K BAND		KS-06-01
3	AN-KS_2	Bench	AN-KS K BAND		KS-06-02
4	AN-KS_3	Bench Optmech Assembly	AN-KS K BAND		KS-06-00
5	AN-KS_3_1	Pre-slit Assembly	AN-KS_3 Bench Optmech...		KS-06-03
6	AN-KS_3_2	Collimator Assembly	AN-KS_3 Bench Optmech...		KS-06-04
7	AN-KS_3_2_1	Collimator Mount	AN-KS_3_2 Collimator Assem...		KS-06-05
8	AN-KS_3_2_2	Collimator Optics	AN-KS_3_2 Collimator Assem...		KS-05-00
9	AN-KS_3_3	Cross-Disperser Assembly	AN-KS_3 Bench Optmech...		KS-06-06
10	AN-KS_3_4	Camera Assembly	AN-KS_3 Bench Optmech...		KS-06-07
11	AN-KS_5	Detector Assembly	AN-KS K BAND		KS-10-00
12	AN-KS_5_1	Detector Head	AN-KS_5 Detector Assembly		KS-10-01
13	AN-KS_5_2	Detector Electronics	AN-KS_5 Detector Assembly		KS-10-02
14	AN-KS_5_3	Detector Connectors	AN-KS_5 Detector Assembly		KS-10-02
15	AN-KS_6	Cryo-Vacuum System	AN-KS K BAND		KS-07-00
16	AN-KS_6_1	Vacuum Vessel	AN-KS_6 Cryo-Vacuum System		KS-07-01
17	AN-KS_6_2	Pumps, Valves, Support Pipes	AN-KS_6 Cryo-Vacuum System		KS-07-02
18	AN-KS_6_3	Heatexchanger	AN-KS_6 Cryo-Vacuum System		KS-07-01
19	AN-KS_6_4	Cooler	AN-KS_6 Cryo-Vacuum System		KS-08-01
20	AN-KS_6_5	LN Supply	AN-KS_6 Cryo-Vacuum System		KS-08-02
21	AN-KS_6_6	Sorption Pump	AN-KS_6 Cryo-Vacuum System		KS-08-03
22	AN-KS_7	Thermal Shielding	AN-KS K BAND		KS-09-00
23	AN-KS_8	Ctrl Electronics	AN-KS K BAND		KS-12-00
24	AN-KS_9	Ctrl Software	AN-KS K BAND		KS-11-00

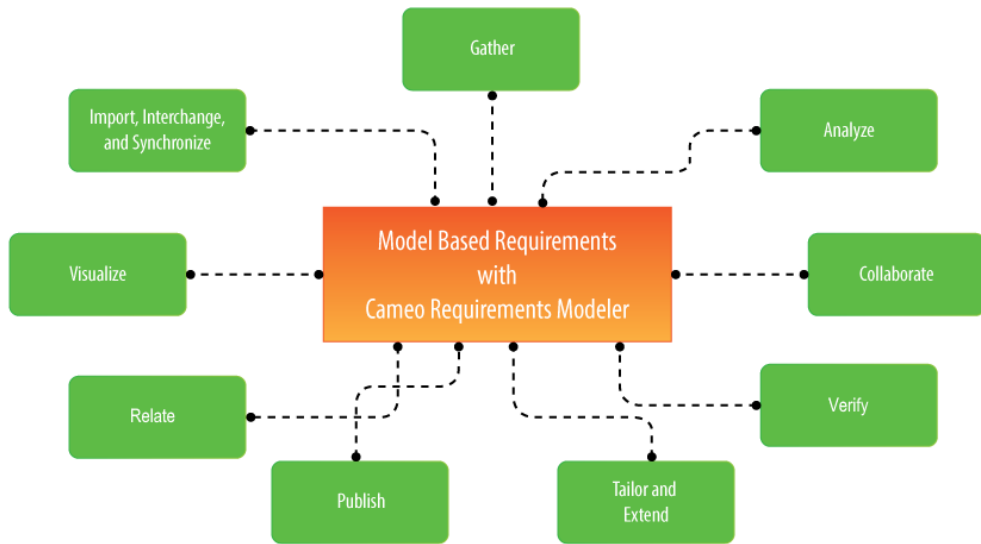




GESTIONE / VERIFICA INTERFACCE



REQUIREMENT DI PROGETTO



Cameo Systems Modeler 2021x - ANDES_model_master.mdzip [Volumes/GoogleDrive/Drive condivisi/ANDES/MODEL/andesreq/]

Diag... Containment Struct... TRS #2-x S: ANDES Tech Req Relations...

Criteria
 Row Element Type: Requirement Column Element Type: Block
 Row Scope: Down Column Scope: ES_WP
 Dependency Criteria: (Implied) Direction: Show Elements:

Legend
 Refine
 Refine (Implied)

AN-00-00 ANDES_WP
 AN-CU-04-00 CU_WP
 AN-AO-03-00 SCAO_W
 AN-FE-03-00 FE_WP
 AN-FL-03-00 FL_WP
 AN-KS-04-00 K-BAND
 AN-RS-04-00 RIZ_WP
 AN-SW-04-00 SW_WP
 AN-US-04-00 UBV_WP
 AN-Y5-04-00 YH_WP
 AN-SI-01-00 Instrum
 AN-SE-01-00 Syst
 AN-SE-02-00 Requi
 AN-SE-03-00 Interf
 AN-SE-04-00 Optic
 AN-SE-05-00 Mech

* ANDES Technical Requirements Specifics 75 39 41 47 47 36 41 36 46 43 24 88 28 32 36 2

Access and Handling
 [R-AND-158] [R-AND-158]
 [R-AND-159] [R-AND-159]
 [R-AND-160] [R-AND-160]

Delivery
 [R-AND-167] [R-AND-167]

Environmental Conditions
 [R-AND-67] [R-AND-67]

Functional and Performance Requirements
 [R-AND-69] [R-AND-69]
 [R-AND-70] [R-AND-70]
 [R-AND-71] [R-AND-71]

Data-flow Requirements
 [R-AND-119] [R-AND-119]
 [R-AND-120] [R-AND-120]
 [R-AND-121] [R-AND-121]

General Calibration Requirements
 [R-AND-110] [R-AND-110]
 [R-AND-111] [R-AND-111]
 [R-AND-112] [R-AND-112]
 [R-AND-113] [R-AND-113]

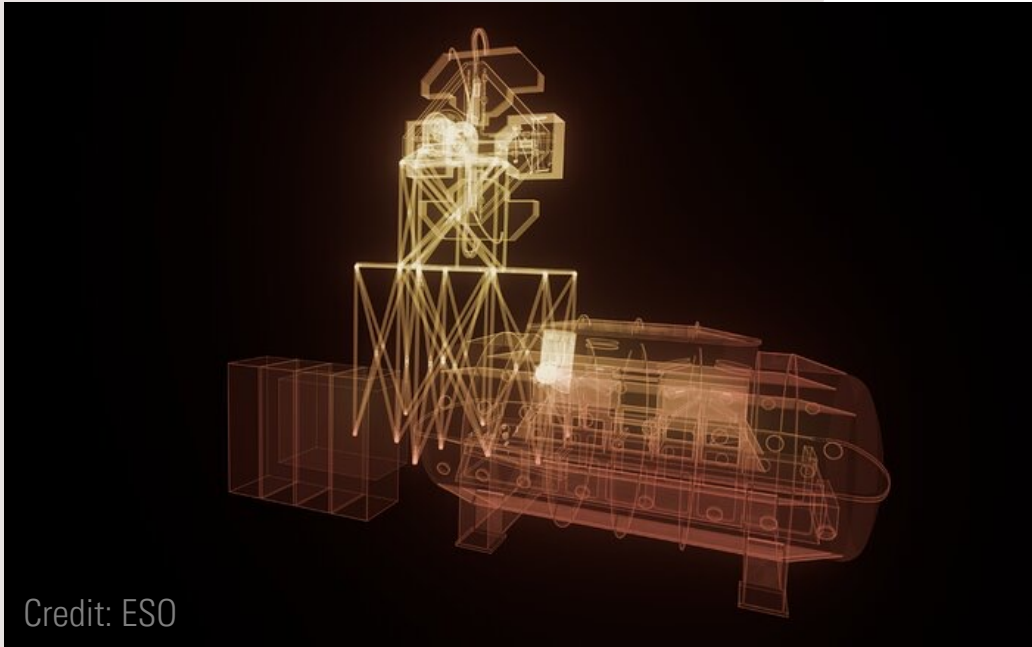
«AstroMSE Requirements»
 TRS #2.1
 Documentation
 "prova"
 Id = "TRS-2.1"
 Text = "the power consumption must not exceed 30 W"

«AstroMSE Requirements»
 TRS #2.1.2
 Achieved Value = "32"
 Id = "TRS-2.1.2"
 Text = "the power consumption must not exceed 20 W"

«AstroMSE Requirements»
 Derived from TRS #2.1
 Id = "6"
 Text = "a solar panel shall be implemented to compensate excessive power loads"

«comments»
 Derive Relationship
 Created when an analysis shows that additional requirements are accomplished by a given requirement.
 Derived requirements generally correspond to requirements at the next level.

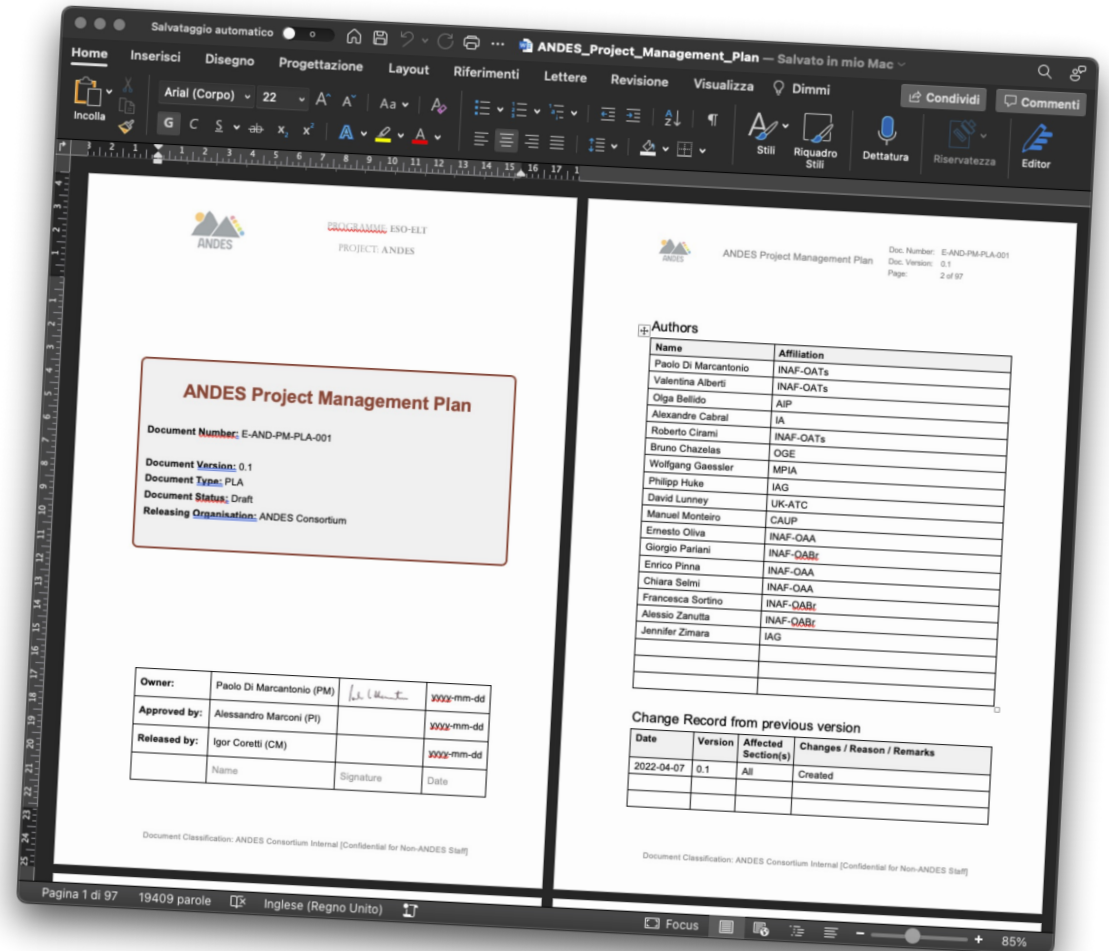
Ready



Credit: ESO

VALIDAZIONE DEL MODELLO E PRODUZIONE AUTOMATICA REPORT

- I blocchi SysML del modello possono rappresentare espressioni matematiche, proprietà fisiche e indicatori di efficacia
- Il tool esegue / risolve il modello mantenendo le dipendenze tra blocchi e parametri
- Si interfaccia con Matlab, Mathematica, etc.



COLLABORAZIONI



con università

Polimi

Insubria

Tesisti (1-2/y), Dottorandi (1/ciclo) e Master (tbd)



con agenzie

ESO: condivisione utilizzo pratico di CAMEO in progetti

JPL (NASA): confront sull'utilizzo di SysML, parallelism con strumentazione da spazio



con osservatori

Padova + Arcetri: condivisione delle metodologie per implementare MBSE. Creazione del "Profilo AstroMBSE" per la personalizzazione in CAMEO e di modelli template per progetti astronomici