MBSE 2021

MODEL-BASED SYSTEM ENGINEERING FOR AVIONICS PROCESSES

B.Attanasio, D.Cellarier, R.De Ferluc

Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

TABLE OF CONTENT

MOTIVATION AND REASONS

More and more Engineering information

/// Gather in tools instead of lost in a series of documents

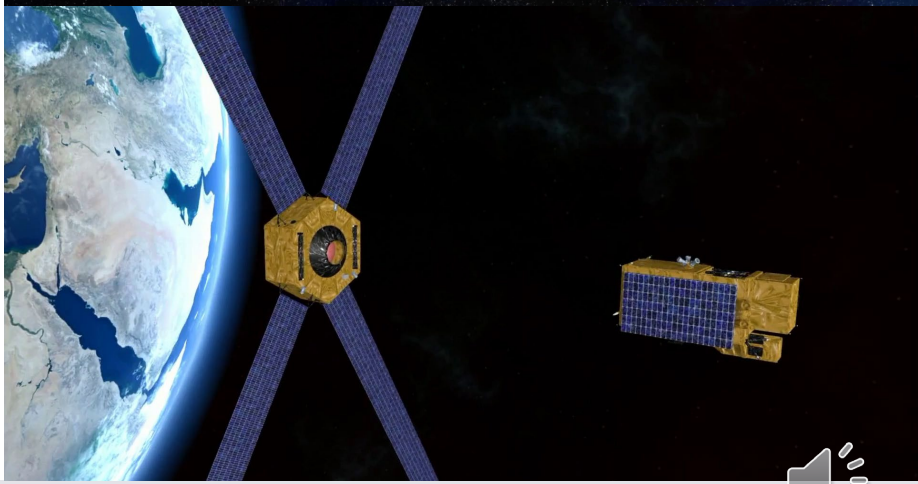
/// Naturally understandable: know where to search for an information

/// Reduce engineering costs and risks

/// Easy to understand at different level.

Main Criteria to improve co-engineering:

- Accepted by the community
- Not time consuming
- No bug



Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

CAPELLA AS A BASIS

/// Use of Capella: MBSE Open Source tool

/// Possibility to have Code generation

/// Development of viewpoints to have specific add-ons

/// Connection to other tools: SDB, Sys2Soft, CCM4Space, MOST

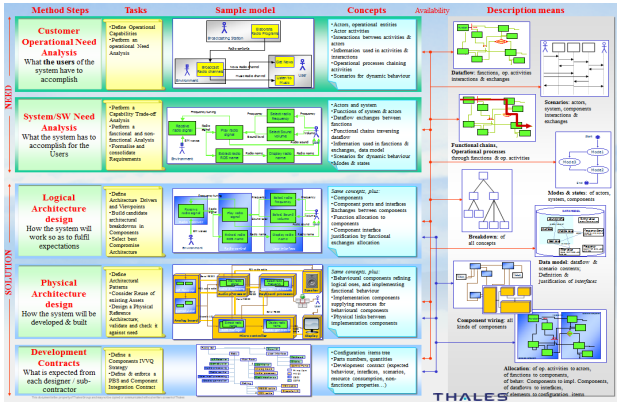
/// Document Exchanges for:

Main Users:

- System Engineer
- Avionics Engineer
- SW/HW Engineer

But also:

- Product Line Manager
- Program Manager
- V&V Manager



Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

PROCESS TO USE REQUIREMENTS

SAVOIR generic OBC specification (SAVOIR-GS-001)

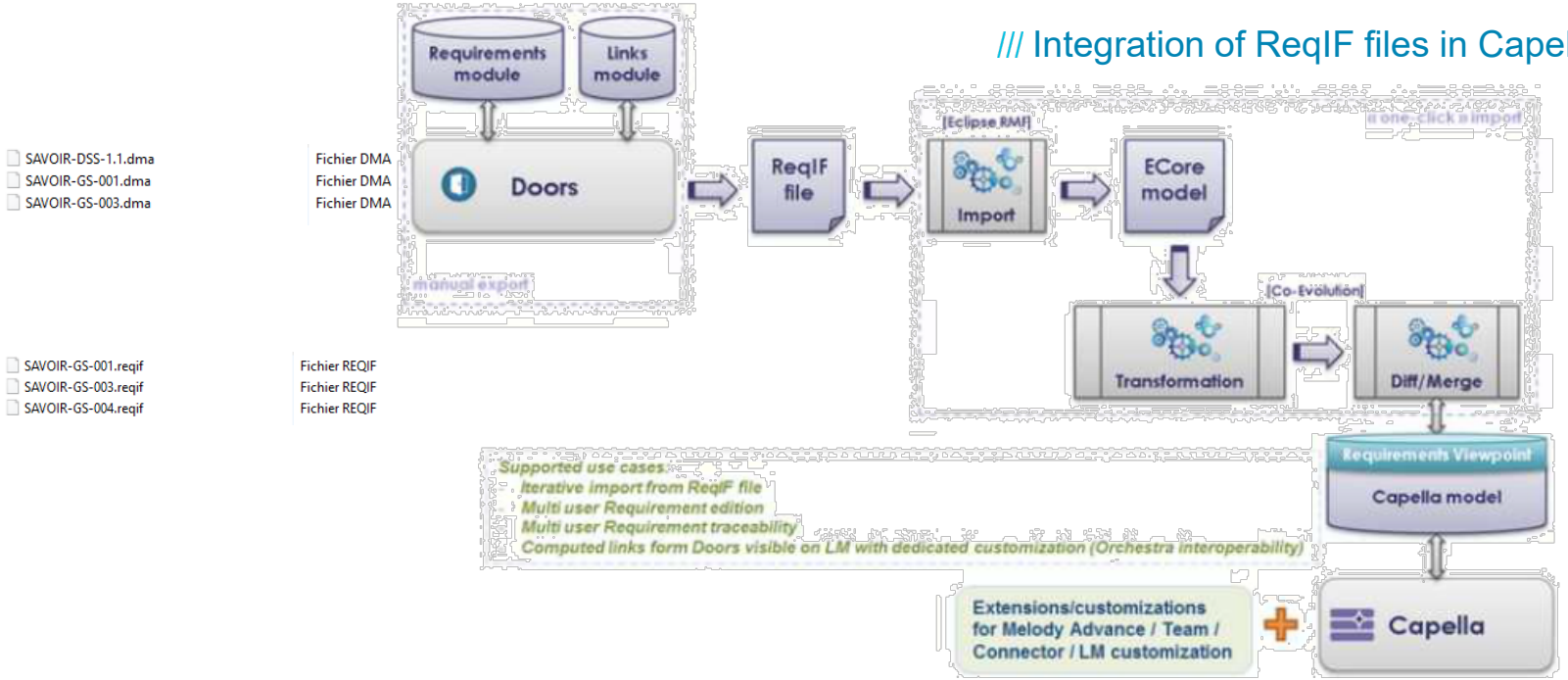
SAVOIR RTU Functional and Operability Requirements (SAVOIR-GS-003)

SAVOIR Data Storage System Requirement Document (SAVOIR-GS-004)

/// Use of DOORS to integrate requirements from documents

/// Generation of ReqIF files

/// Integration of ReqIF files in Capella

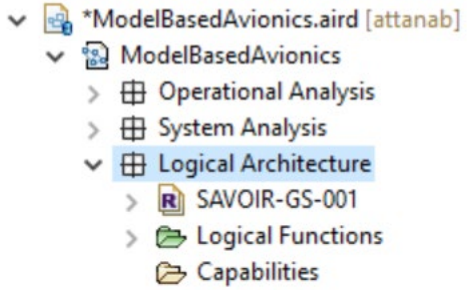


Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

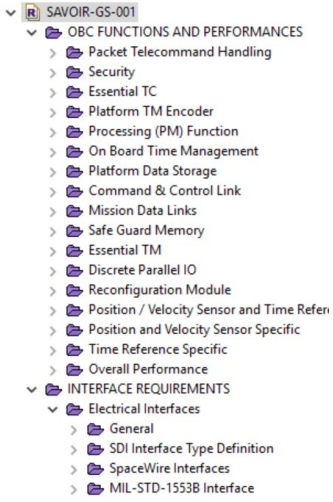
REQUIREMENTS IN CAPELLA

/// Capella Project Explorer

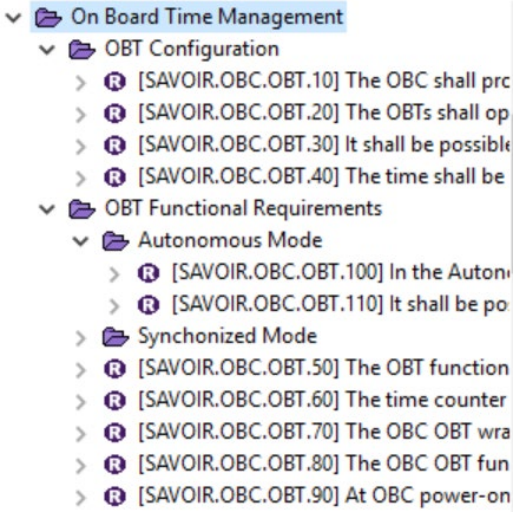
SAVOIR-GS-001 imported



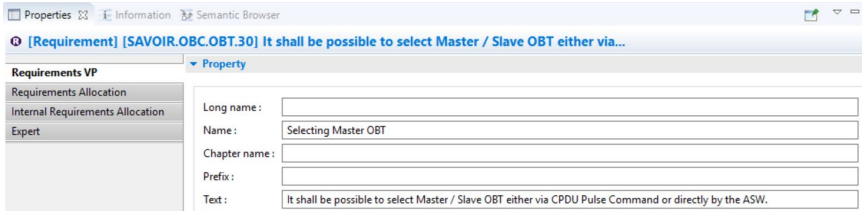
Section by section: Avionics functions



Example of one Avionics function



/// Requirement Allocation



In properties, the text of the requirement is present

Requirement allocation enable to map it on a logical function or a functional exchange or whatever

Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

MODELLING TO SIMULATION

/// Perform On-Board Spacecraft Architecture:

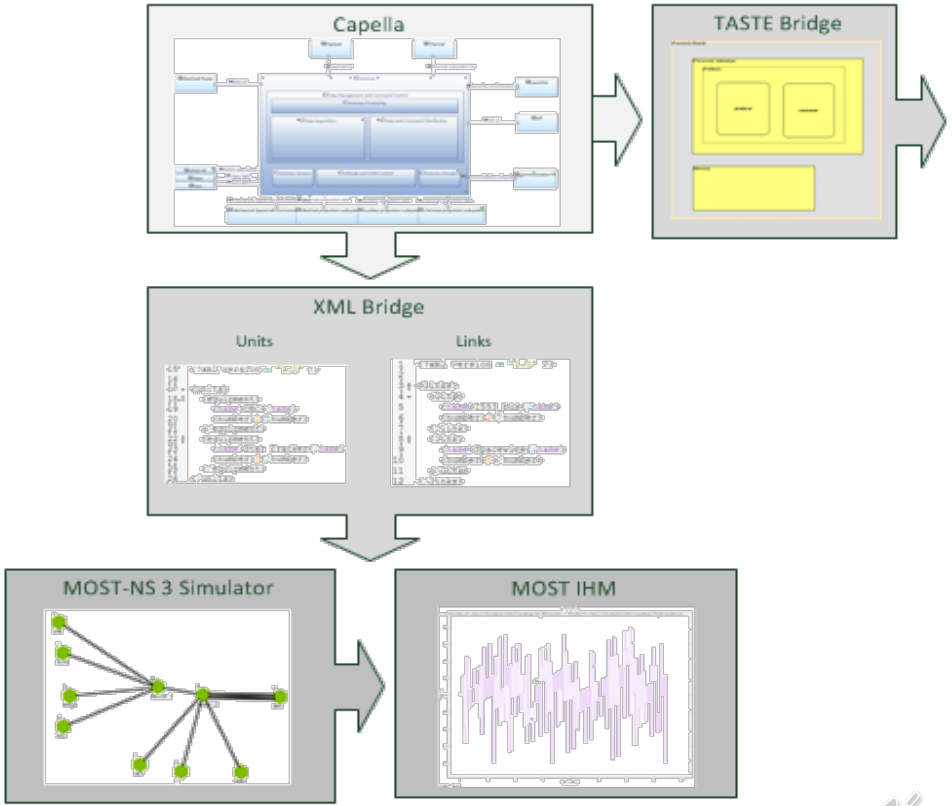
- Introduce requirement
- Verify the requirements and validate the architecture

/// TAS wants to link modelling tools to simulation tools

- Capella : System Modelling
- TASTE : SW Modelling
- MOST : on-board communication network simulations

/// Viewpoint developed for each protocol

- 1553
- CAN
- SpaceWire
- SpaceFibre



Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

MODIFICATION OF PROCESS

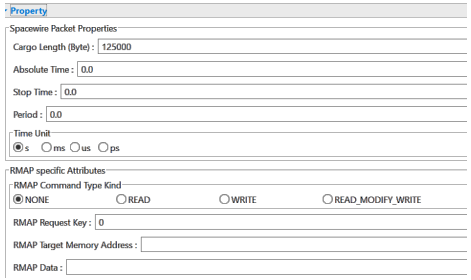
/// Old World

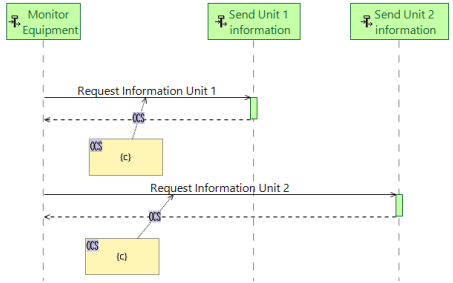
- Excel Definition
- No Simulation

	Traffic Description						
	Kind of Data	Nb	Communication Direction	Max Cargo size (bits)	Frequency (Hz)	StartTime (us)	Latency (ms)
ePMS 1	Control Command Data	1	OBC ==> RT	1024	1	50	1
	Payload Data FFT	1	RT ==> ICC	572	9770	200	
	Payload Data Science	1	RT ==> OBC	6261	4	100	
	Payload Data DFACs	1	RT ==> OBC	3444	16	300	<1ms
	SC 1 Data Science	1	RT ==> OBC	30000	1	600000	
	HK	10	RT ==> OBC	1024	1	100	10
ePMS 2	Control Command Data	1	OBC ==> RT	1024	1	100	1
	Payload Data FFT	1	RT ==> ICC	572	9770	400	
	Payload Data Science	1	RT ==> OBC	6261	4	200	
	Payload Data DFACs	1	RT ==> OBC	3444	16	100	<1ms
	SC 2 Data Science	1	RT ==> OBC	30000	1	800000	
	HK	10	RT ==> OBC	1024	1	300	10
GRS FEE 1	Control Command Data	1	OBC ==> RT	1024	1	200	1
	Payload Data	1	OBC ==> RT	800	16	300	<1ms
	Config Data	1	OBC ==> RT	2048	random	300 000	10
	Payload Data	1	RT ==> OBC	416	16	100	<1ms
	HK	10	RT ==> OBC	128	1	100	10
GRS FEE 2	Control Command Data	1	OBC ==> RT	1024	1	100	1
	Payload Data	1	OBC ==> RT	800	16	500	<1ms
	Config Data	1	OBC ==> RT	2048	random	500 000	10
	Payload Data	1	RT ==> OBC	416	16	200	<1ms
	HK	10	RT ==> OBC	128	1	300	10
Laser 1	Control Command Data	1	OBC ==> RT	1024	1	400	1
	Payload Data	1	RT ==> OBC	544	16	100	0,1
	Config Data	1	OBC ==> RT	128000	once	100	10
	HK	10	RT ==> OBC	128	1	300	10
Laser 2	Control Command Data	1	OBC ==> RT	1024	1	100	1
	Payload Data	1	RT ==> OBC	544	16	200	0,1
	Config Data	1	OBC ==> RT	128000	once	400	10
	HK	10	RT ==> OBC	128	1	300	10

/// New World

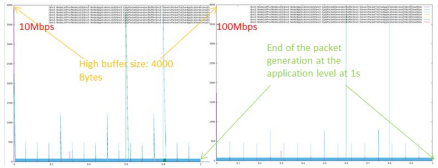
- Attributes and properties on the model
- Simulation





/// Results

- Buffer Occupation
- Latencies



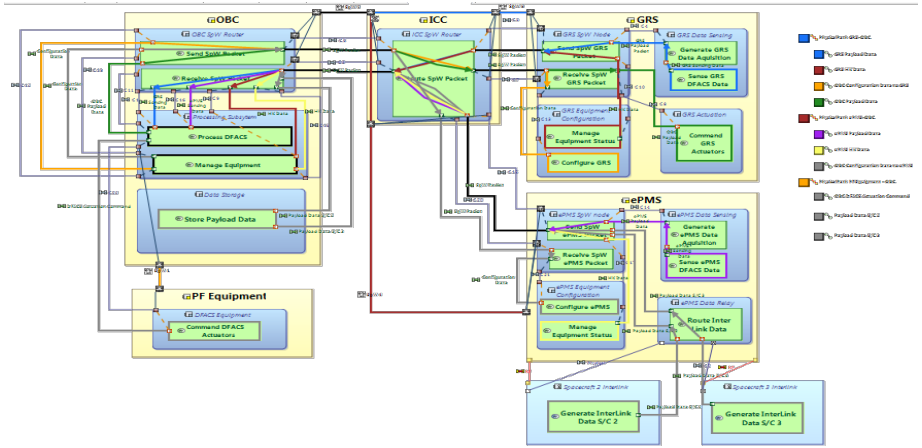
	OBC	ePMS1	ePMS2	GRS1	GRS2	Laser1	Laser2	Node_SW1	Node_SW2
Packets sent	43	9796	9794	17	17	17	17	0	0
Packet Received	112	1	1	18	18	2	2	19546	1

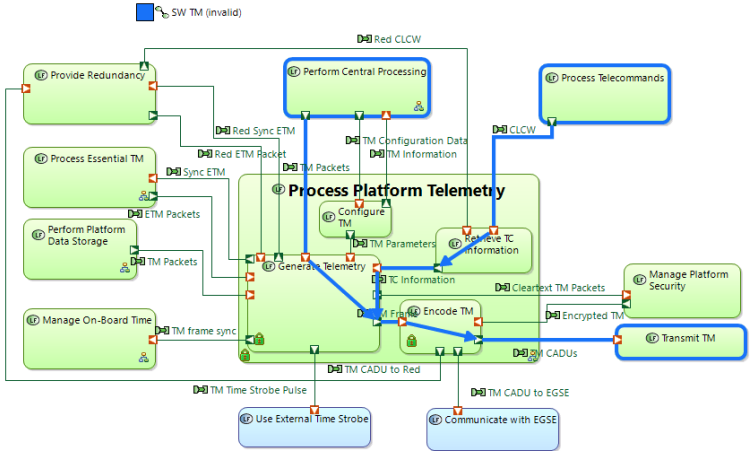
Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

REAL CASES

/// SAVOIR implementation for Requirement Allocation

- model developed of the functional reference architecture at Capella Logical level
- SAVOIR req integrated in the model & Mapping on the model
- Model developed at physical layer for HW/SW implementation





/// LISA Phase A/B1 for simulation

- One functional chain by kind of traffic
- Definition of the network/bus
- All the physical nodes are represented

Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

MBSE IN FDIR

/// Benefits of models for FDIR process

- FDIR often comes late in the project, because it currently requires the SDB to exist
- Models would allow to manage complexity and perform early V&V

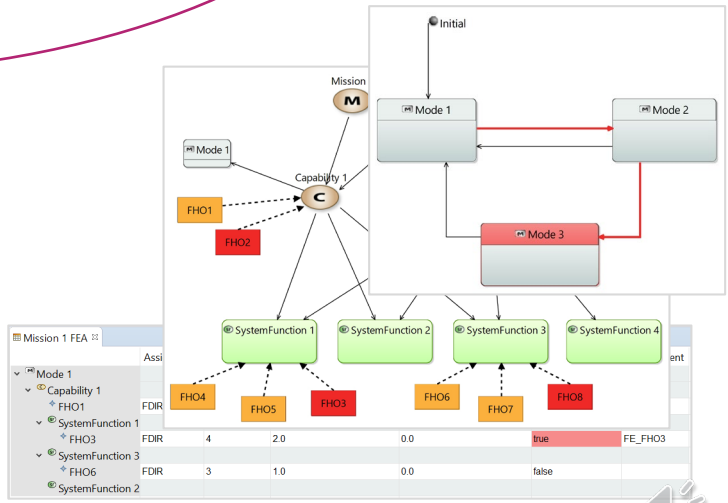
/// MBSE for FDIR in Thales Alenia Space

- Past and current process presented in a dedicated session

/// Model-Based FDIR Design

- On-going activity to develop a Capella-based toolchain to support FDIR Design, based on a specified process
- Follow-on activity will implement early V&V

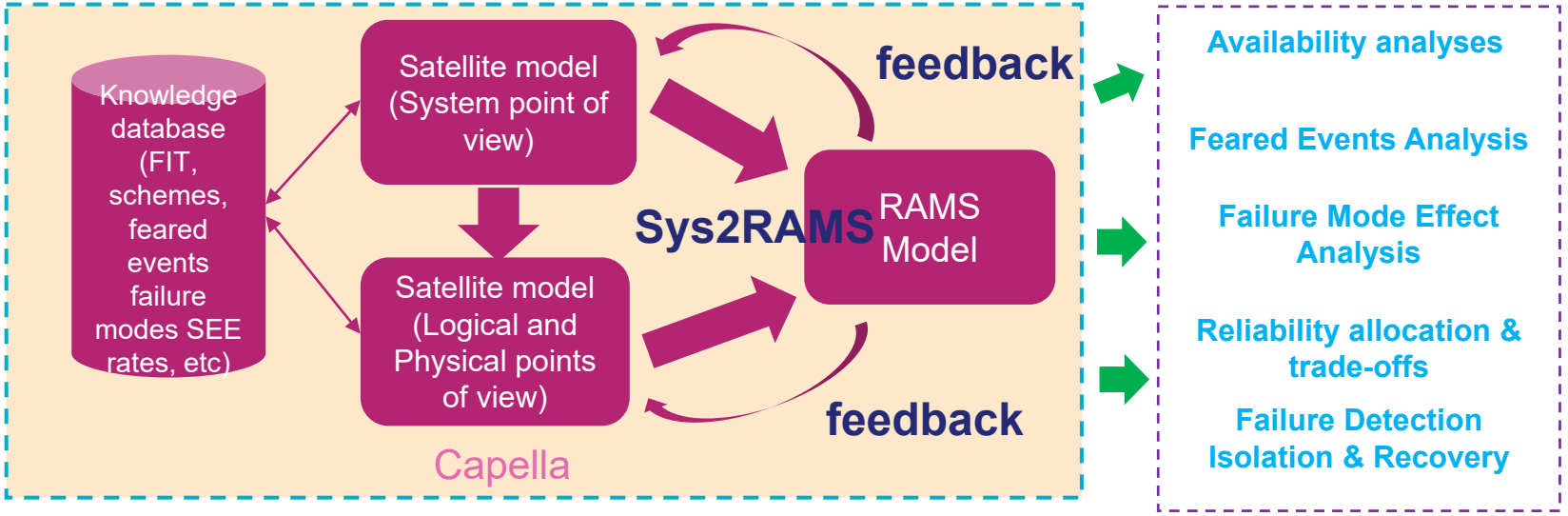
BENEFITS OF MODEL-BASED SYSTEM ENGINEERING FOR FDIR



Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

MBSE IN RAMS

/// Models used for RAMS analyses an Overview Approach

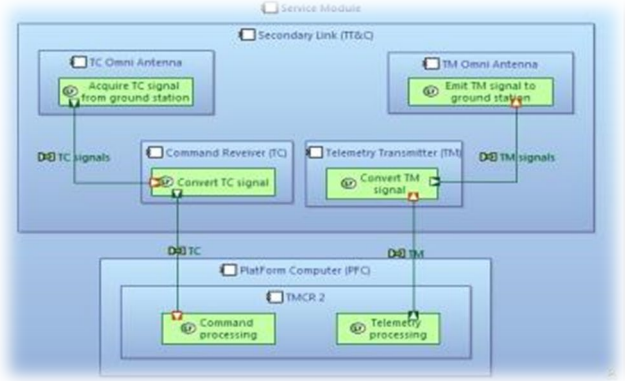


Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

MBSE IN RAMS

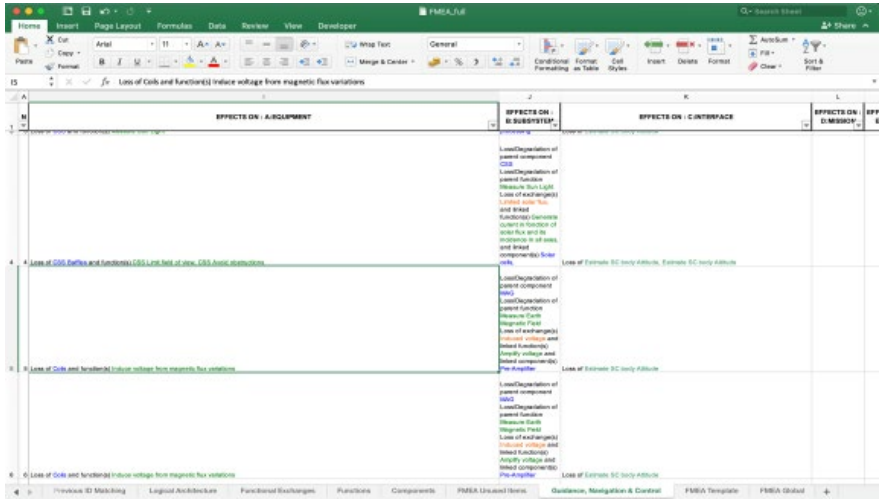
/// Capella Fault Management Viewpoint: Link between Model and Database

Capella models



Failures database

Automatically filled FMEA in Excel

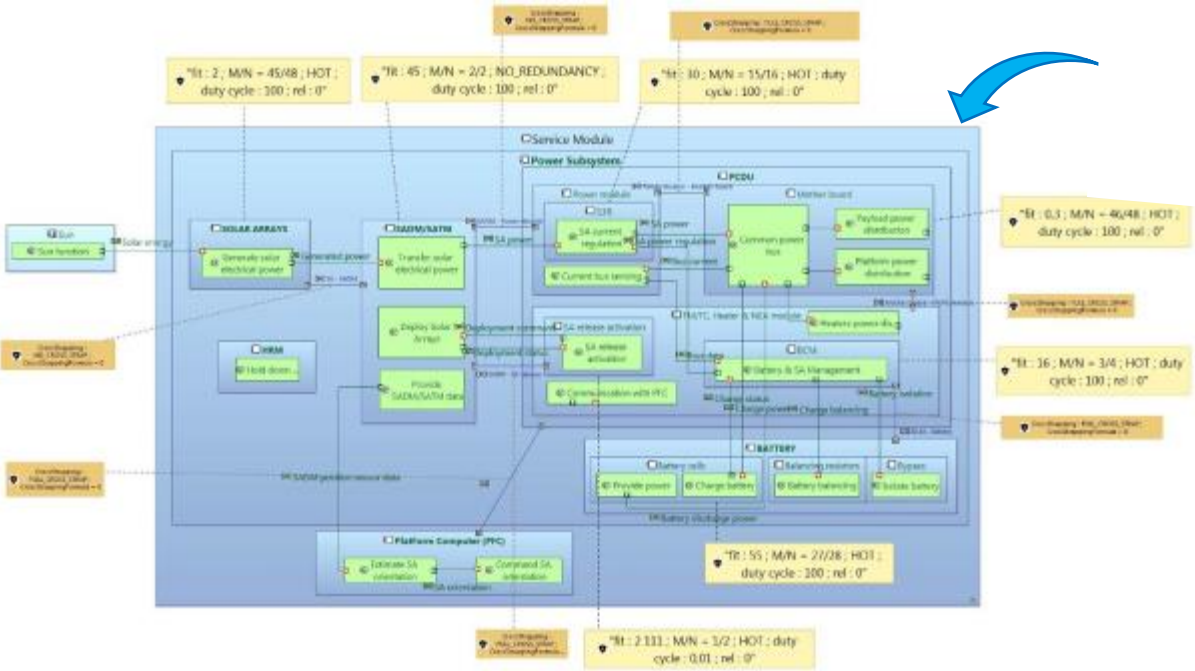


Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

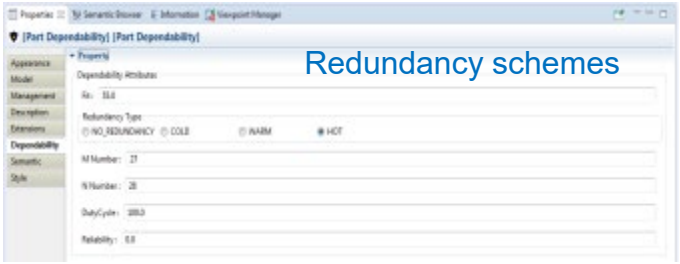
RELIABILITY VIEWPOINT

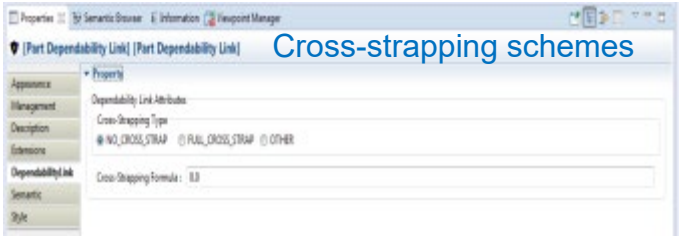
/// Capella Reliability Viewpoint

- **At Logical level** : preferred solution



Reliability parameters under RAMS responsibility





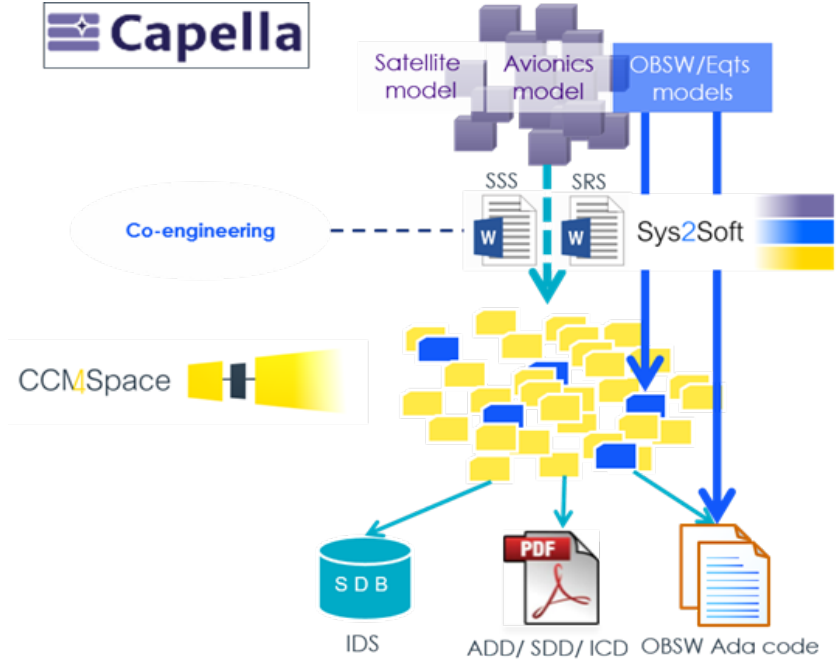
Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

AVIONICS TO SW

/// System-SW Factory in Thales Alenia Space : Sys2Soft

- Model-Based toolchain to improve co-engineering between avionics and SW teams
- Capella Viewpoint
  - Productive data modelling, built-in verifications, design consolidation
- Tooled transformation
  - Capella → CCM4Space : correct by construction SW model
- Partial code generation for equipment managers
  - Equipment parameter acquisition, unit tests…

Enables fast and 0-cost modifications in case of changes of Observability and Commandability



/// Other outputs from Capella Equipment model:

- SRS OBSW: use cases + spec of OBSW services
- IRD for EQ supplier: e.g. spec of 1553 communication protocol
- SRS Simu: Spec of simulated model in S/C simulator

Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

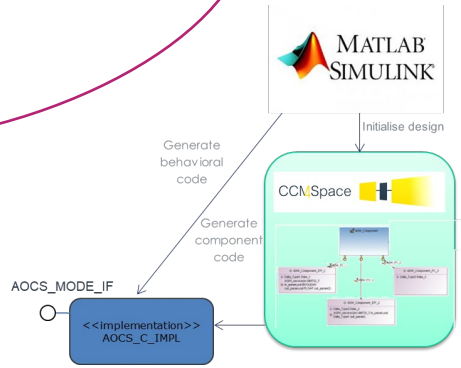
AVIONICS TO SW

EXTENDING THE SCALE OF OUR MODELLING ENVIRONMENTS WITH CFS AND SEDS

/// System-SW Factory: R&D activities

Electronic Data Sheets

- Key enabler for several areas, like interface modelling, code generation of EQ drivers code, EQ simulation, …
- Prototype of an EDS→Capella transition tool performed in the frame of the GSTP EDS
- Integration of EDS in CCM4Space for Lunar Gateway Programmes → Other presentation

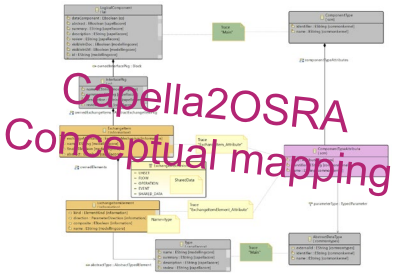


Autocoding

- An established process relates modelling of control application in Matlab/Simulink and SW architecture
- An on-going ESA Study aims at performing early V&V on those models

Capella2OSRA

- SAVOIR On-board SW Reference Architecture
- On-going ESA study to consolidate and extend the tooled transition from Capella to OSRA in the frame of ESA's « *digital continuum* » toolchain



Date: 28/09/2021
Ref: Not referenced
Template: 83230347-DOC-TAS-EN-009

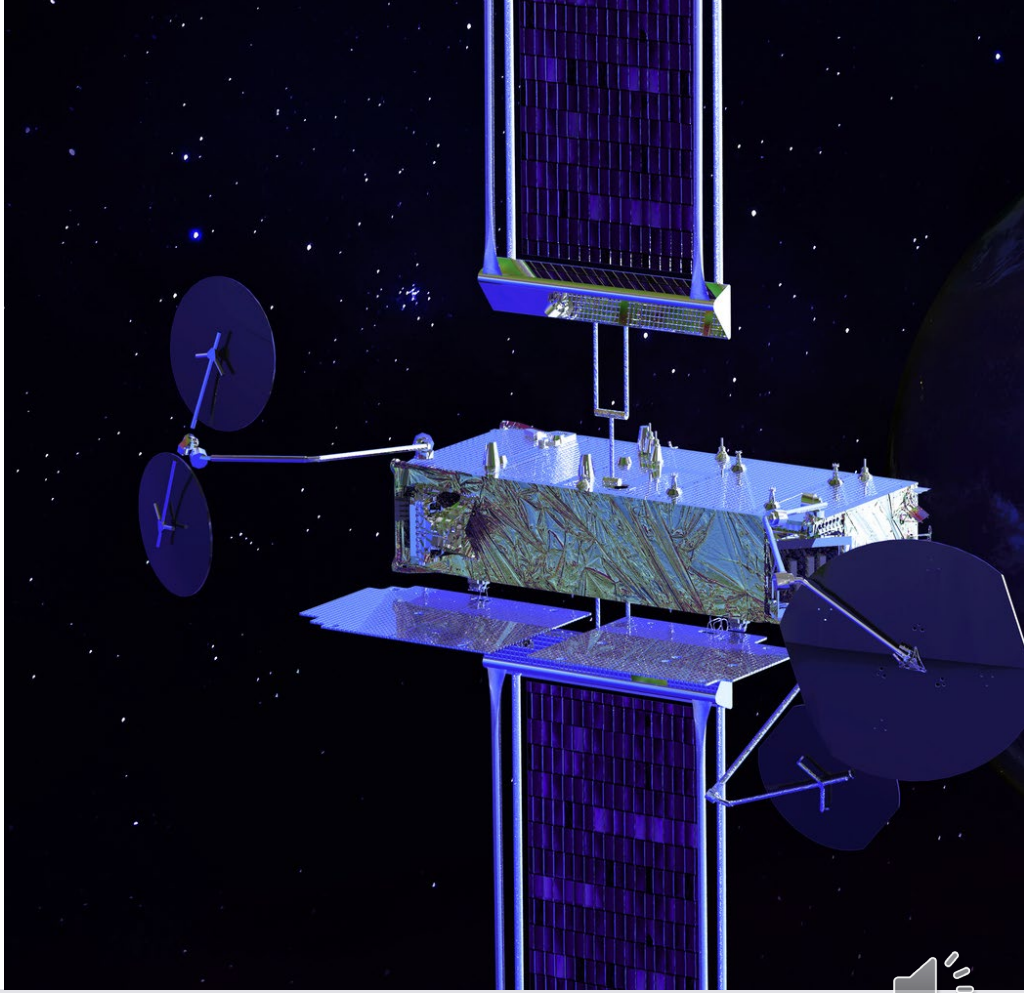
CONCLUSION

- The models are now commonly used in all the disciplines, HW, SW, Avionics, RAMS…

- Coordination of all these R&D activities in TAS but also in programs:

➔ Use on concrete cases

- ultimate challenge is to reach a digital continuity to federate all the different approaches into a global model-based process



Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009

QUESTIONS?

Date: 28/09/2021
Ref: 0005-0014441973
Template: 83230347-DOC-TAS-EN-009