

MBSE 2021

MODEL-BASED SYSTEM ENGINEERING FOR AVIONICS PROCESSES

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ThalesAlenia

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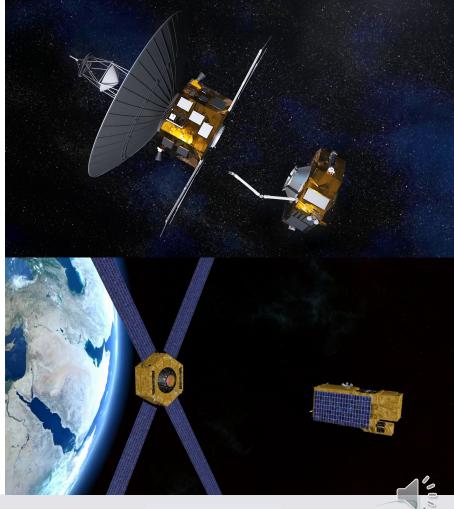
MOTIVATION AND REASONS

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
- **I** Not time consuming
- No bug



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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:

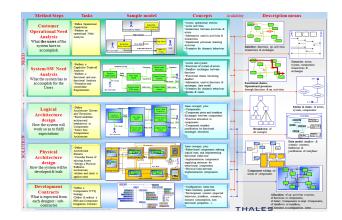
- System Engineer
- Avionics Engineer
- SW/HW Engineer

But also:

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





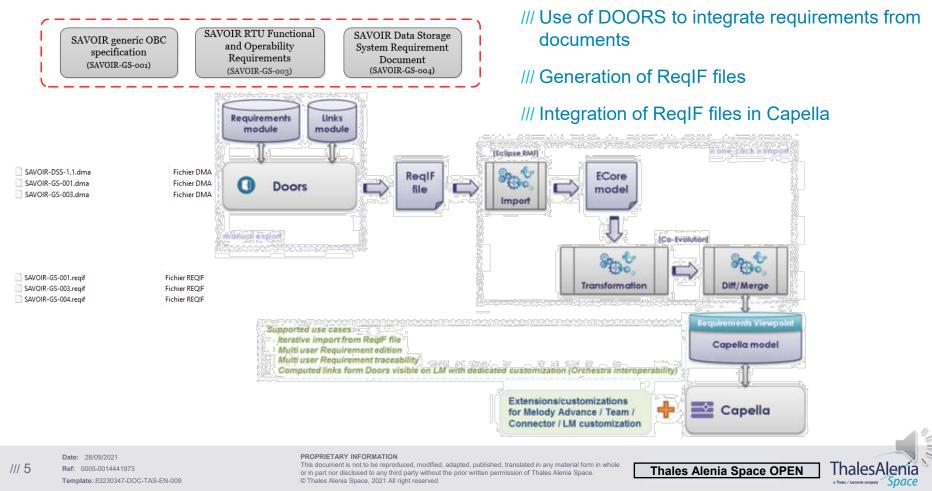


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PROCESS TO USE REQUIREMENTS



REQUIREMENTS IN CAPELLA

/// Capella Project Explorer

SAVOIR-GS-001 imported

- ✓ → ModelBasedAvionics.aird [attanab]
 - ModelBasedAvionics
 - > 🗄 Operational Analysis
 - > 🗄 System Analysis
 - Logical Architecture
 - > R SAVOIR-GS-001
 - > 🗁 Logical Functions
 - Capabilities

/// Requirement Allocation

TProperties 💥 👔 Information 😿 Semantic Browser

@ [Requirement] [SAVOIR.OBC.OBT.30] It shall be possible to select Master / Slave OBT either via..

Requirements VP	▼ Property	
Requirements Allocation		
Internal Requirements Allocation	Long name :	
Expert	Name :	Selecting Master OBT
	Chapter name :	
	Prefix :	
	Text :	It shall be possible to select Master / Slave OBT either via CPDU Pulse Command or directly by the ASW.

Section by section: Avionics functions

- SAVOIR-GS-001
 - OBC FUNCTIONS AND PERFORMANCES
 - Packet Telecommand Handling
 Escurity
 - Essential TC
 - > 🔁 Platform TM Encoder
 - > > Processing (PM) Function
 - 🗁 On Board Time Management
 - > 🗁 Platform Data Storage
 - > Command & Control Link
 - > 🗁 Mission Data Links
 - 🕞 🗁 Safe Guard Memory
 - > 🗁 Essential TM
 - > 🗁 Discrete Parallel IO
 - > 🗁 Reconfiguration Module
 - > 🗁 Position / Velocity Sensor and Time Refer
 - > 🕞 Position and Velocity Sensor Specific
 - > 🗁 Time Reference Specific
 - > Dverall Performance
 > INTERFACE REQUIREMENTS
 - Electrical Interfaces
 - > 🗁 General
 - > 📂 SDI Interface Type Definition
 - > 🗁 SpaceWire Interfaces

7 -

> MIL-STD-1553B Interface

Example of one Avionics function

- 🗸 🗁 On Board Time Management
 - ✓ ▷ OBT Configuration
 - > ③ [SAVOIR.OBC.OBT.10] The OBC shall prc
 - SAVOIR.OBC.OBT.20] The OBTs shall op
 - SAVOIR.OBC.OBT.30] It shall be possible
 - SAVOIR.OBC.OBT.40] The time shall be
 - OBT Functional Requirements
 - 🗸 🗁 Autonomous Mode
 - > (SAVOIR.OBC.OBT.100] In the Auton
 - > (SAVOIR.OBC.OBT.110] It shall be por
 - > > Synchonized Mode

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- SAVOIR.OBC.OBT.50] The OBT function
- SAVOIR.OBC.OBT.60] The time counter
- SAVOIR.OBC.OBT.70] The OBC OBT wra
- > ③ [SAVOIR.OBC.OBT.80] The OBC OBT fun
- SAVOIR.OBC.OBT.90] At OBC power-on

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



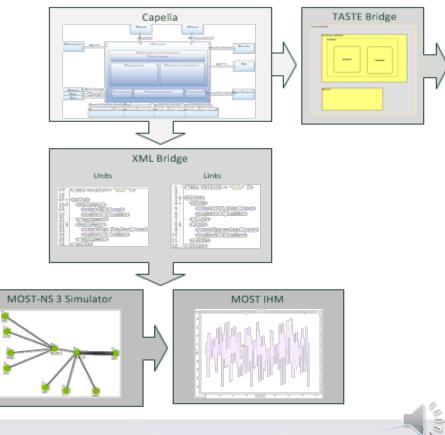
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- /// Perform On-Board Spacecraft Architecture:
- Introduce requirement
- / Verify the requirements and validate the architecture
- /// TAS wants to link modelling tools to simulation tools
- I Capella : System Modelling
- I TASTE : SW Modelling
- MOST : on-board communication network simulations
- /// Viewpoint developed for each protocol
- **1**553
- CAN
- SpaceWire
- SpaceFibre



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MODIFICATION OF PROCESS

/// Old World

- Excel Definition
- No Simulation

				Traffic De	scription		
	Kind of Data	Nb	Communica tion Direction	Max Cargo size (bits)	Frequency (Hz)	StartTime (us)	Latency (ms)
ePMS1	Control Command Data	1	OBC ==> RT	1024	1	50	1
	Payload Data FFT	1	RT ==> ICC	572	9770	200	
	Payload Data Science		RT ==> OBC	6261	4	100	
	Payload Data DFACs		RT ==> OBC	3444	16	300	<1ms
	SC1Data Science		RT ==> OBC	30000	1	600000	
	HK		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		RT ==> OBC	6261	4	200	
Ę	Payload Data DFACs		RT ==> OBC	3444	16	100	<1ms
Ψ.	SC 2 Data Science	1	RT ==> OBC	30000	1	800000	
	HK		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
	Pavload Data	1	OBC ==> RT	800	16	500	<1ms
Ë	Config Data	1	OBC ==> RT	2048	random	500 000	10
ů.	Payload Data	1	RT ==> OBC	416	16	200	<1ms
0	HK	10	RT ==> OBC	128	1	300	10
Laser 1	Control Command Data	1	OBC ==> RT	1024	1	400	1
	Pavload Data		RT ==> OBC	544	16	100	0,1
	Config Data	1	OBC ==> RT	128000	once	100	10
	HK	10	RT ==> OBC	128	1	300	10
2	Control Command Data	1	OBC ==> RT	1024	1	100	1
e, '	Payload Data	1	RT ==> OBC	544	16	200	0,1
aser	Config Data	1	OBC ==> RT	128000	once	400	10
_	HK	10	RT ==> OBC	128	1	300	10

/// New World

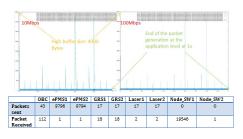
Attributes and properties on the model

Simulation

Property	Monitor	Send Unit 1
Spacewire Packet Properties	Equipment	" information
Cargo Length (Byte) : 125000		
Absolute Time : 0.0	I	I. I.
Stop Time : 0.0	Request Informa	tion Unit 1
Period : 0.0	l≪00S	
Time Unit ●s Oms Ous Ops	0CS (c)	
RMAP specific Attributes ∩RMAP Command Type Kind	Re	quest Information Unit 2
NONE O READ O WRITE O READ_MODIFY_WRITE		7 1
RMAP Request Key : 0 RMAP Target Memory Address :	(C)	
RMAP Data :		1

/// Results

- Buffer Occupation
- Latencies



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♣ Send Unit 2 information

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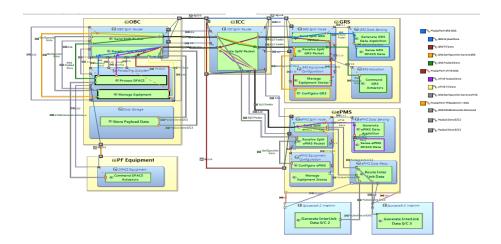


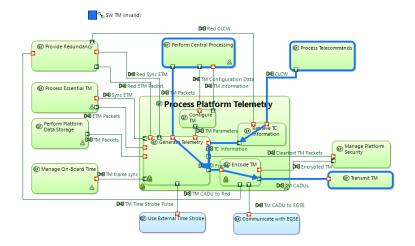
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REAL CASES

/// 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

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



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MBSE IN FDIR

/// Benefits of models for FDIR process

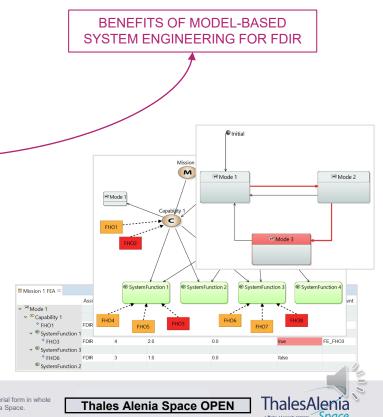
- FDIR often comes late in the project, because it currently requires the SDB to exist
- Models would allow to manage complexity and perform early V&V

/// MBSE for FDIR in Thales Alenia Space

Past and current process presented in a dedicated session

/// Model-Based FDIR Design

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

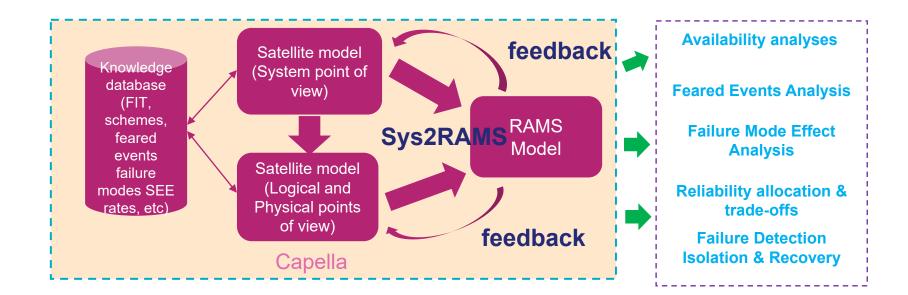


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MBSE IN RAMS

/// Models used for RAMS analyses an Overview Approach



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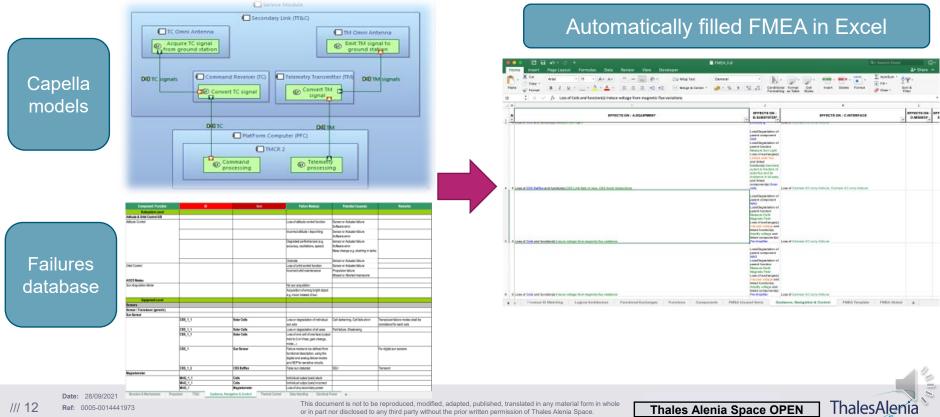
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MBSE IN RAMS

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



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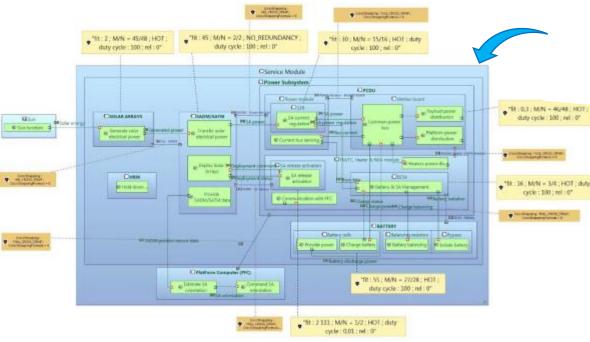
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RELIABILITY VIEWPOINT

/// Capella Reliability Viewpoint

At Logical level : preferred solution



Reliability parameters under RAMS responsibility

CONSTANT OF	+ Property	Redundancy schemes
toder	Dependebility Rttributer	Reduindancy serietites
lanagement	Sec. 11.0	
exception	Relations Type	
taniets	© NO,RELADANCY © COLE © NAM	10H #
epondability smartic (de	MNamber: 21	
	Silunder: 28	
	DulyCpile: 2003	
	feldsity: EI	

Fart Depend	ability Unit Part Dependability Unit Cross-strapping schemes				
Аррилися	* humb				
Hangement	. Dependability: Link Attributes				
Description	Cost-Singsing Type				
Intensione	● NO, DIOS, STAAF () RAU, DIOS, STAAF () OTHER				
Vependabilityl ink	Coo Stapping Tomake: 13				
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AVIONICS TO SW

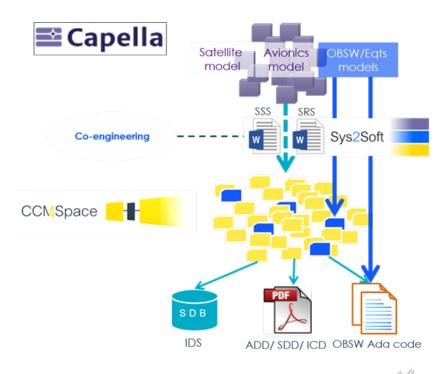
/// System-SW Factory in Thales Alenia Space : Sys2Soft

- Model-Based toolchain to improve co-engineering between avionics and SW teams
- Capella Viewpoint
- Productive data modelling, built-in verifications, design consolidation
- I 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



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AVIONICS TO SW

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

I Electronic Data Sheets

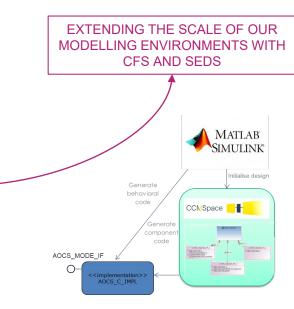
- Key enabler for several areas, like interface modelling, code generation of EQ drivers code, EQ simulation, ...
- Prototype of an EDS→Capella transition tool performed in the frame of the GSTP EDS
- Integration of EDS in CCM4Space for Lunar Gateway Programmes → Other presentation

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





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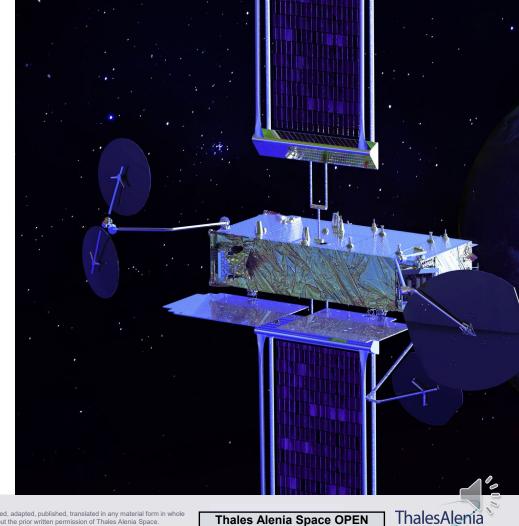
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CONCLUSION

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



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QUESTIONS?

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