

RHEA

0

G

R

U P

Final Presentation









FP Participants

- Gwendolyn Kolfschoten (RHEA)
- Paloma Maestro Redondo (RHEA)
- Antoine Théate (RHEA)
- Sam Gerené (RHEA)
- Martin Risseuw (ATG)
- Jeroen Rauws (ATG)
- Charlie Madier (HDG)
- Julien Baclet (IRT)
- Jean Marie- Gauthier (IRT)















Key Challenges in Reviewing MBSE models

- MBSE has the risk of closing people out, reading and navigating models is more complex than reading documentation
- Reviewers may be experts in their fields but not necessarily experts in MBSE
- The complexity of space systems requires a team of reviewers, thus reviewing becomes increasingly a collaborative effort
- Feedback to an MBSE model requires model context to remain understandable



Objectives

- **Objective #1:** To identify non-expert users' needs for interaction with a digital system model during the lifecycle of a space mission and exploit state-of-the-art technologies for the most effective interaction with the model.
- **Objective #2:** To develop and validate a prototype of a User Interaction Environment (UIE) to TRL3.
- **Objective #3:** To define a roadmap for implementation of the UIE for model-based reviews at ESA, specifically in a concurrent environment.



Steps in the project





Schedule











WPDs

WPDs





Document Deliverables

ID	Title	Milestone(s)	Folder
TN1	Interaction with a Digital System Model User Needs and Gap Analysis	UNR	DJF
UR	Interaction with a Digital System Model User Requirements	UNR	RB
ANNEX1_UR	Detailed User Requirements	UNR	RB
ANNEX1_TN1	Painpoints vs Userneeds Matrix	UNR	DJF
UR2	Updated User Requirements	TSR	RB
ANNEX1_UR2	Updated Detailed User Requirements	TSR	RB
TN2	Interaction with a Digital System Model Technology Trade-Off	TSR	DJF
TN2_MBSE_Tool_Assessment	TN2 - MBSE Tool UI Assessment	TSR	DJF
TN2_MBSE_Tool_Highlights	TN2 - MBSE Tool Highlights	TSR	DJF
TS	Interaction with a Digital System Model Software Architecture and Specifications	TSR	TS
SDVP	Interaction with a Digital System Model Software Development and Validation Plan	TSR	DJF
DDD	Interaction with a Digital System Model Software Definition and Description	AR	DDF
SUM1.1	Interaction with a Digital System Model Software User Manual	AR	DDF
SRF	Software Reuse File	TSR, AR, FR	DJF
SUM1.2	Interaction with a Digital System Model Software User Manual	FR	DDF
TR	Interaction with a Digital System Model Test Report	FR	DJF
TDP	Technical Data Package	FR	
TAS	Technology Achievement Summary	FR	MGT
FP	Interaction with a Digital System Model Final Presentation	FR	MGT
ESR	Executive Summary Report	FR	MGT
FR	Interaction with a Digital System Model Final Report	FR	MGT
CCD	Contract Closure Documentation	СС	MGT





Software Deliverables

- Docker compose file
- UI-DSM Application source code
- rep4 file \rightarrow Mass budget

ID	Title	Milestone(s)	Folder
SW1.1	Interaction with a Digital System Model Software	AR	SW
SW1.2	Interaction with a Digital System Model Software (Updated)	FR	SW

Model Deliverables

- Enterprise Architect model defining the software architecture
- COMET Engineering Model

ID	Title
UI_DSM_TS_v5.eapx	Interaction with a Digital System Model Architecture Model – Enterprise Architect model and generated report and files defining the software architecture
UI_DSM_COMET_EngineeringModel	COMET Engineering Model of the mission EnVision used for development, testing and validation



Task 1 – User Needs and Pain-points



Identifying user needs and painpoints

Interviews

- 17 interviews
- Characteristics: levels of expertise (from novice to expert), position (systems engineers, team leaders, industrial partners), usages of the tools (modellers, reviewers, requirements engineers), and field of expertise (traceability, engineering budget, concurrent design review practices, etc).

Survey ("Lime Survey")

- 41 participants
- Participants to CDF sessions, system engineers, MBSE expert users and projects using MBSE.
- Additionally, it was also shared with several MBSE groups with industry.



Combined user needs and pain-points





Identified Use Cases

Model Consistency
Learning/Documentation
Opening Projects/Models
Customising User Interface
Interaction with the Tool
Work on Models
Find things in Models
Presentation for Review
Review Item Discrepancy (RID)
Manage RIDs
Create/Edit Models
Change Models
Create Budgets
Review Budgets
Requirement Management
Collaboration
Licensing
Document Generation
Verification of Model Consistency

	Pain (Average)	Value (Average)	Sum Average
Model Consistency	3.2	3.1	6.3
Learning/Documentation	3.1	3.1	6.2
Customising User Interface	3.5	3.5	7
Interaction with the Tool	2.9	2.9	5.8
Work on Models	2.9	2.8	5.7
Find things in Models	3.8	3.5	7.3
Presentation for Review	3.8	4	7.8
Review Item Discrepancy (RID)	3.2	3.3	6.5
Manage RIDs	2.7	3.1	5.8
Change Models	3.6	3.2	6.8
Create Budgets	3.2	2.9	6.1
Review Budgets	3.4	3.4	6.8
Requirement Management	3.3	3.7	7
Collaboration	3.8	4	7.8
Verification of Model Consistency	3.6	3.5	7.1



Selected Use Cases







Selected Use Cases





Resulting user journey Structure





List of User Journeys

- UJ1: Check the requirements completeness
- UJ2: Check the requirements functional allocation completeness
- UJ3: Check the function to physical allocation completeness and adequateness
- UJ4: Check the budget review (mass/power/data)
- UJ5: Check the architecture interfaces consistency and completeness



Task 2 – Technology trade-off



2. Trade-off Criteria

User Needs

- Improve screen real-estate issues
- Reduce visual density and improve an outdated feature style
- Improve focus on relevant information
- Improve model clarity and user understanding through guidance
- Automate and/or reduce time spent cleaning models
- Improve user confidence through clear feedback
- Improve traceability
- Improve collaborative work on a model & usability for reviews that take place in a concurrent environment
- Improve understanding of 3d models in context



- Find things in Models
- Presentation for Review
- <u>Collaboration</u>
- Change Models
- Review Budgets
- Verification of Model Consistency

Requirements

- Adequateness to E-TM-10-25
- Fit with current and planned infrastructure at the Agency
- Usability across the project lifecycle (outside reviews)
- TRL
- Performance
- License Conditions
- Cost



Technology Trade-off

- Criteria 1: Effectiveness of the Human-Machine Interaction, in addressing the User Needs identified in TN1
- Criteria 2: Adequateness to the interaction process, methodology and User Needs for the specific use-cases defined in UR
- Criteria 3: Adequateness to the specific characteristics of the models typically built, exchanged and used in the space sector
- Criteria 4: Usability for reviews that take place in a concurrent environment
- Criteria 5: Feasibility of potential implementation with the current and planned infrastructure at the Agency
- Criteria 6: Usability across the project lifecycle (outside reviews)
- Criteria 7: Technology maturity (TRL)

ATG

RHEF

Technology	C1	C2	C3	C4	C5	C 6	C7
Commercial MBSE tools	Low	Med	Med	High	Med	High	8-9
Open source MBSE tools	Med	High	High	High	High	High	6-7
Commercial simulation tools	Low	Low	Low	Med	Low	Med	n/a
CDF implementations	Low	Low	Low	High	Low	Low	n/a
Web-based collaboration tools	Low	Med	Low	High	Low	Low	8-9
Web-based frameworks	High	High	Med	High	High	High	n/a
Realtime 3D rendering	Med	Low	Low	Low	Med	Med	n/a
AI supported methods	Low	Med	Low	Low	Med	Med	n/a
VR headsets	Med	Low	Low	Low	Med	Med	6-7
AR headsets	Med	Low	Low	Low	Med	Med	5-6
HUD headsets	Low	Low	Low	Low	Low	Low	6-7
Touch screen/Smart Boards	Med	Med	Med	Med	Med	Med	8-9
Drawing tablets	Low	Med	Med	Low	Med	Med	8-9
Hand Tracking Devices	Low	Low	Low	Low	Low	Low	5-6
Volumetric displays	Low	Low	Low	Med	Low	Low	5-6
Stereoscopic displays	Low	Low	Low	Med	Low	Low	5-6

Combining user needs and State-of-the-Art technology

Steps

Identify Key technologies relevant to MBSE

Identifying current MBSE tools and features to support Collaboration and Reviewing

Comparing use cases with SotA technology and matching them to the project objectives and scope

Decision making with the agency to select usecases and technology choice

Work out user Journey and viewpoints

Use-cases vs project objectives vs State-of-the-Art technology

Use Case Summary	1: update COMET	2: Web 2d Environment	3: Web 3d viewer	4: AR / VR Auth Tool	Comment	Fit with project focus
 Presentation for Review Option to compare models or check their version history Different views to show models, modelling, reviewing or presentations Giving feedback directly with the tool, add notes or comments to the models Notify users when they are mentioned in comments or when elements owned by them have a new comment or note. 					In a stripped web environment, the model can be presented in a very efficient way. Either to navigate through it, find changes, or see dependencies. If a 3d model is available or 3d Mock-up, a viewer can be integrated either natively or web-based. The web environment can have an easy to use commenting system.	
9. Review Item Discrepancy (RID) Allowing users to review the RIDs directly in the tool, with options to filter or comment on the RIDs Tracking of RID changes					Requires a back-end change to store RIDs. Display can be done in COMET or a web viewer.	
 Manage RIDS Create and maintain RIDs directly in the MBSE tool Set and update the RID status in the tool 					Requires a back-end change to store RIDs. Display can be done in COMET or a web viewer.	
 Create/Edit Models Re-use models , use pre-filled models or templates Display a list of components and parameters when users want to change several values at once, being able to directly fill in all the values in a list Creating mind maps in the MBSE tools 					Best use-case for Geometry first approach. Would work in COMET natively or web based solution if it allows for authoring.	



MBSE Tool comparison

- While most MBSE tools have the information required for the review tasks (views) they almost all experience the same pain point.
- The few that experience less pain points solve these in a web interface

MBSE Tool	Cameo Systems Modeler	Capella & Team for Capella	Enterprise Architect	COMET	IDM-CIC	Valispace	Prolaborate	Innoslate
Views								
RequirementTraceabilityToProductView	YES	YES	YES	YES	NO	YES	YES	YES
RequirementTraceabilityToRequirementView	YES	YES	YES	YES	NO	YES	YES	YES
RequirementVerificationControlView	NO	Partial	YES	YES	NO	YES	YES	YES
RequirementBreakdownStructureView	YES	YES	YES	YES	NO	YES	YES	YES
RequirementTraceabilityToFunctionView	NO	YES	YES	YES	NO	Partial	YES	?
ReviewItemVersionCompareView	YES	Partial	YES	YES	NO	YES	YES	?
PhysicalFlowView	YES	YES	YES	YES	?	?	YES	?
ProductBreakdownStructureView	YES	YES	YES	YES	YES	YES	YES	?
InterfaceView	YES	YES	YES	YES	?	?	YES	?
BudgetView	YES	YES	YES	YES	YES	YES	YES	YES
FunctionalBreakdownStructureView	YES	YES	YES	YES	?	?	YES	?
FunctionalTraceabilityToProductView	NO	YES	YES	YES	?	?	YES	?
High level pain points								
1. Hardware used	YES	YES	YES	YES	YES	partial	Partial	Partial
2. User interface	YES	YES	Partial	YES	Partial	YES	YES	Partial
3. Lack of guidance	YES	YES	YES	YES	YES	Partial	NO	?
4. Loss of focus	YES	Partial	Partial	Partial	Partial	Partial	NO	Partial
5. Lack of collaborative features	YES	YES	YES	Partial	Partial	NO	Partial	Partial
6. Changes management	YES	YES	YES	Partial	NO	YES	YES	?



Task 3 – Development



Task 3 – Prototype Development

• Inputs:

- TN1 (User Needs and Gap Analysis)
- UR2 (Updated User Requirements)
- TS (Technical Specification)
- SDVP (Software Development and Validation Plan)
- Workshop outputs: User journeys & Viewpoints
- Analysis of review objectives and tasks with experts
 → Focus on PRR & SRR







Task 3 – Prototype Development

- Initial planning and coordination between RHEA & ATG
- New mock-ups with updated design to support first discussions about the needed functionalities
- Definition of a new COMET Model to support development, testing & validation
- Development of the back-end
- Connection between back-end and front-end
- Continuous testing
- Iterative internal meetings
- Iterative meetings with The Agency (bi-weekly)
- Additional Progress Meeting (1st December)



Task		ΙΟΡ		Search	n Bar		U	ser Set	tings
Review Objectives & Tasks Information Check production	$\widehat{\square} \qquad \leftarrow \rightarrow$ Home \rightarrow UI-DSM Critical Revie	Nav	igation Options w > PRR - 3 > Check function alloca	Q search				A	
	Review objective Verify the completeness, adequacy ar consistency of the preliminary design compliance with the ESA requiremen Tasks	✓ nd n and ts. ✓	Check function allocation	Filter Column	Product Description Name According ShortName Owner Container Serving	Clerometer Box ACC_box AOGNC ice Module ()	Context Panel		
	Check budgets. Check if requirements are allow to functions adequately.	⊘ cated	prod/func Biprop Pressure Regulator Biprop Pyro Valve	Acquire the required spacecraft attitude	Control and monitor all the necessary ΔV manoeuvres	⊘ Control the required : attitude	Parameters Implement function(s) Satisfies requirement(s) Mark as Revie t	^ ^ wed	
	Check function allocation to products. Check requirements verification. Do completeness check		 Accelerometer Box Adapter Ring O □ Battery 	~	~		Related views	~	Related Views
			Biprop Thruster Main Engine Biprop Thruster RCS		~		 <i>P</i>roduct Breakdown <i>P</i>Interface Comments 	~	Commonto
			Bottom Panel Coarse Sun Sensor Electronic Power Conditioning	~			Leave a comm admin 31/01/2023 13:54:48	n ent Open ∨	
			Gvroscope Astrix	7		*	Margin can be reduced ?	e 🕞 Link	

Task 3 – Developed Solution



Admin &

Task 3 – Developed Solution – Review Objectives and Tasks



A

D Comments A A D Comments 0/0

D Comments

Task 3 – Developed Solution – Management Functionalities

$\widehat{\square} \leftarrow \rightarrow$	Q search		А
Home 💚 User Management			
User management			음* Add user
UserName E	Details	Delete	
admin	View details		
atheate	View details	Delete	
$\widehat{\square} \leftarrow \rightarrow$	Q search		A
Home \geq EnVision \geq Review 1 \geq PRR - 1			
PRR - 1 Verify the completeness, adequacy and consistency of the preli plan.	minary management, design and develop	ment, product assurance and associated assembly, i	ntegration and verification (AIV)
Objective tasks	Assign Participants	×	
Review available/linked documentation.	Participants : SYS	~	Assign to Comments O/0
Read related requirements.	ACC atheate	~	Assign to Comments 0/0
Check consistency of the related requirements.		Assign	Assign to Comments 0/0



Task 3 – Developed Solution – Traceability View

				Q	search									A
Home > UI-DSM Critical Review > Review > PRR - 2 > Do completeness check.														
Review objective 🗸 🗸												Relationship D	escription	~
Verify the proper translation and allocation of	Do complete	eness che ion - Iteration	8 @ Regu	uirement Ti	raceability	To Require	ment					Source Elemen	t	^
the ESA mission requirements into a set of system and subsystem technical specifications														~
in terms of completeness, adequacy and consistency.	View settings								V	Filter	Column	ID	DH-0	080
									-			Name	General interfac	ces
Tasks 🗸	req/req	CPROP-020	CPROP-040	DH-010	DH-080	DH-090	MA-010	MA-020	MA-040	MIS-010	MIS-020	Description		
Read requirements.	AOCS-010				~							The DHS shall be sensors/actuator subsystem and P	able to interface to s needed for AOCS ropulsion subsystem	
	AOCS-020					~						Owner	D	HS
Do completeness check.	AOCS-030			\checkmark								Requirement type	Interfa	ace
	AOCS-120				~							Verification metho	od t/	est
Check relationships between									,			Verification stage	pre-laun	nch
requirements and requirements flow down.									~	✓ ✓		Justification	justification for gene interfac	eral
	○ CPROP-010							\checkmark		\checkmark		Derivation from		~
	CPROP-050						~					Derivation to		^
	CPROP-070											Traces		^
	MA-030									~		Traced by		^
	MIS-010							~			_	Satisfied by functi	on(s)	^
								•				Satisfied by produ	uct(s)	^
	MIS-070		\checkmark									Parametric Constr	aints	^
	4										Þ	Associated Catego	ories	^



Task 3 – Developed Solution – Breakdown View

$\widehat{\square} \leftarrow \rightarrow$		Q search		А
Home > EnVision > Envision Iteration 8 > UI DSN	1 - EnVision - Iteration 8			
		ⓒ Chemical Propulsion - Baseline	Columns Element Descr	iption V
			Name	SRS Matching Network
Name	Owner	Categories	ShortName	SRS_MH
▼ *A*	* *A*	T *A*	Owner	INS
			Container	SRS Module (i)
✓ EnVision	SYS	Missions	Parameters	~
► ♂ Ground Segment	GS	Segments	accessibility	7 (-)
Launch Segment	SYS	Segments	Dimension	[DimX, DimY, DimZ]
 Space Segment 	SYS	Segments	mass	1.3 (kg)
	0.0		mass margin	30 (%)
✓ Spacecraft	SYS	Systems	number of items	1 (-)
✓ Payload Module	INS	Elements, Payload	Position	[x, y, z]
Radio Science Experiment	SYS	Equipment, Instruments, Payload	Shape Kind	Вох
▼ SRS Module	INS		Related views	~
SRS Matching Network	INS		P Requirement	Breakdown
SRS Receiver	INS		→ 🔗 Requirement	Verification Control



Task 3 – Developed Solution – Breakdown View Requirements

							^															
		D					Requirement Desc	ription														
equii	rement	Breakdown					ID	MI														
							Name	Launch Specifi														
					¥ Filter		Description															
Specific	ation † Gr	oup 1					The mission shall mak 6.2 launcher	e use of the Aria														
	ID	Name	Definition	Categories	Requirement Type	Derives From	Owner															
		Traine			Requirement type	Denves from	Requirement type	Ν														
Specific	cation: Mission Re	quirements					Verification method	insp														
↓ Gr	roup:						Verification stage	quali														
0	MIS-010	Back-up launch	The mission shall include a back-up launch	Requirements, Mission Requirements	Mission		Justification Ju	stification for la speci														
C	3 MIS-020	Launch Specification	The mission shall make use of the Ariane 6.2 launcher	Requirements, Mission Requirements	Mission		Derivation from															
	MIS-030	Cost	The cost of the mission shall be compatible with an M-size mission	Cost, Requirements, Mission Requirements	Design		Derivation to															
0	MIS-040	Nominal science lifetime	The mission shall have a nominal science phase of 4 venus Mission Analysis. Requirements, Mission Analysis, Mission Analysis, Mission Mission Mission	The mission shall have a nominal science phase of 4 venus Avission Analysis, Requirements, Mission Avission Requirements Avission Requirements Avission Avis	The mission shall have a nominal science phase of 4 venus Mission Analysis, Requirements, Mission Analysis, Mission Mission Quees, with a possible extension of 2 extra cycles Requirements		The mission shall have a nominal science phase of 4 venus Mission Analysis, Requirements, Mission cycles, with a possible extension of 2 extra cycles Requirements Mission		The mission shall have a nominal science phase of 4 venus cycles, with a possible extension of 2 extra cycles Mission Analysis, Requirements, Mission Mission Mission	Infetime The mission shall have a nominal science phase of 4 venus cycles, with a possible extension of 2 extra cycles Mission Analysis, Requirements, Mission Requirements Mission	time The mission shall have a nominal science phase of 4 venus cycles, with a possible extension of 2 extra cycles Requirements Mission Requirements Mission	The mission shall have a nominal science phase of 4 venus Mission Analysis, Requirements, Mission cycles, with a possible extension of 2 extra cycles Requirements Mission	The mission shall have a nominal science phase of 4 venus Mission Analysis, Requirements, Mission cycles, with a possible extension of 2 extra cycles Requirements Mission		The mission shall have a nominal science phase of 4 venus Mission Analysis, Requirements, Mission Analysis, Requirements Mission	The mission shall have a nominal science phase of 4 venus cycles, with a possible extension of 2 extra cycles Requirements Mission		The mission shall have a nominal science phase of 4 venus Mission Analysis, Requirements, Mission cycles, with a possible extension of 2 extra cycles Requirements Mission			Traces Traced by	
	MIS-050	Venus orbit type	The spacecraft shall orbit Venus in a near polar Low Venus orbit	Requirements, Mission Requirements	Mission		Satisfied by function(s)														
C	了 MIS-060	Venus orbit prediction	The orbit shall be predicted with an accuracy of 300 m cross- track, 3km radial for a timespan of 7 days in advance	Requirements, Mission Requirements	Operational		Satisfied by product(s))														
Q	3 MIS-070	TRL	The TRL level should be 5 at the mission selection phase and 6 by mission adoption $% \left({{\left[{{K_{\rm s}} \right]} \right]_{\rm source}}} \right)$	Requirements, Mission Requirements, Product Assurance	ProductAssurance		Parametric Constraint	s														
	MIS-080	Mass	The total launch mass (wet mass + launch vehicle) shall not exceed the launch performance mass (=2870 kg)	Requirements, Mission Requirements	Physical		Associated Categories															
Q	2,						Related views															



Task 3 – Developed Solution – Interface View

View settings				▼ Filter □ Column:
Name	Owner	Interface Nature	Source	Target
Y *A*	T *A*	Y *A*	Y *A*	* A*
Accelerometer Box.Port_	ACC SYS	Structural Interfaces	Accelerometer Box.Port_ACC (O	Assembly Panel PlusZ.Port_ACC
Assembly Panel MinusY	.Port_ SYS	Structural Interfaces	Assembly Panel MinusY.Port_AP	Shear Panels SW.Port_AP4 (IN
Assembly Panel MinusZ	.Port_ SYS	Structural Interfaces	Assembly Panel MinusZ.Port_AP	Shear Panels SW.Port_AP2 (IN
Assembly Panel MinusZ	.Port_ SYS	Structural Interfaces	Assembly Panel MinusZ.Port_VE	VenSpec H.Port_VEN_H (INPUT)
Assembly Panel PlusY.Po	ort_AF SYS	Structural Interfaces	Assembly Panel PlusY.Port_AP (I	Shear Panels SW.Port_AP3 (IN
Assembly Panel PlusZ.Pc	ort_AF SYS	Structural Interfaces	Assembly Panel PlusZ.Port_AP (I	Shear Panels SW.Port_AP1 (IN
Assembly Panel PlusZ.Pc	ort_AF SYS	Structural Interfaces	Assembly Panel PlusZ.Port_AP	HGA Bracket.Port_AP_HGA (INP
Battery.Port_BAT (OUTP	UT) – SYS	Structural Interfaces	Battery.Port_BAT (OUTPUT)	Bottom Panel.Port_BAT (IN_OUT)
Battery.Port_PW_28V (C	DUTPL SYS	Power Interfaces	Battery.Port_PW_28V (OUTPUT)	Power Conditioning and Distrib
High Gain Antenna.Port	_HGA SYS	Structural Interfaces	High Gain Antenna.Port_HGA_B	HGA Bracket.Port_HGA_BR (IN
Low Gain Antenna.Port_	LGA i SYS	Structural Interfaces	Low Gain Antenna.Port_LGA (O	High Gain Antenna.Port_LGA (I
Power Conditioning and	Distr SYS	Structural Interfaces	Power Conditioning and Distrib	Bottom Panel.Port BP PCDU (I



Task 3 – Developed Solution – Physical Architecture/Physical Flow





Task 3 – Developed Solution – Budget View

Charle burden to							Product Descript	ion 🕚	~
Check budgets.							Name	Adapter Ring Mounting	ıgs
UI DSM - EnVision - Iteration 8 💿 Budget							ShortName	AR	М
							onorthanne		
Select Report Definition: MassBudgetEquipment							Owner	ST	TR
							Container	Service Module ((i)
	• +		A B		я				
	T	C2	יטי יכן		Я		Parameters	/	^
				PDF			Implement function(-)	
				XLS		^ 🔅	Implement function(5)	
							Satisfies requirement	(s)	^
Model: UI DSM - EnVision				XLSX		Q			
Iteration: Revailion B Option: Chemical Propulsion - Baseline				RTF		- •	(∕√Mark	as Reviewed	
Mass Budget per Equipment							0		
Equipment	Margin Mo	del Mass	Calc. Mass	DOCX					
- Space Segment			818.76	MHT			Related views	`	~
- Service Module	200		587.58						
Accelerometer Box	20%	35.60	42 72	HTML			Requirement Bre	akdown	
Adapter Ring Mountings	20%	9.00	10.80	T .			C- Requirement bre	akuowii	
Assembly Panel MinusY	20%	8.00	9.60	lext			Functional Break	down	
Assembly Panel MinusZ	20%	8.00	9.60	CSV					
Assembly Panel PlusY	20%	8.00	9.60	CSV			Product Breakdo	wn	
Assembly Panel PlusZ	20%	8.00	9.60	Image			•		
Bettery	10%	67.20	73.92	mage			C Interface		
Biprop Fill Drein Valve	5%	0.07	0.07						
Biprop Filter	5%	0.08	0.08				_		
Biprop HP Transducer	5%	0.22	0.23				Comments		~
Biprop Latch Valve	5%	0.55	0.58						
Birop LP Iranducer	5%	0.25	0.26				<u> </u>		
Biprop Non Return Valve	276	5.00	6.00				() Leav	e a comment	
Binore Pressue Benulator	5%	1 20	1.26						
Biprop Pyro Valve	5%	0.16	0.17						
Biprop Thruster Main Engine	5%	4.30	4.51						
Biprop Thruster RCS	5%	0.65	0.68						
Black Paint	10%	1.12	1.23						
Bottom Fanel	20%	10.40	12.48						
Coarse Sun Sensor	5%	0.22	0.23			~			
- · · · · · · · · · · ·						•			



Task 3 – Developed Solution – Budget View

	- 1 - 1				
< <	1 of 1 🔹 🔪 🔀	- 75%	• + 22 8	읍 ⊥. <	к л
					^ 3
	Model: UI DSM - EnVision Iteration: Iteration 8				c
	Option: Chemical Propulsion - Baselin	e Mass Budget per Equipment			
	Equipment - Space Segment + Service Module		Margin Model Mass Colc. Mas 818.7 587.5	6	
	+ Payload Module		231.1	8	
	Service 1	odule			



Task 3 – Developed Solution – Search Bar

		÷	\rightarrow	Q search		AD
Hom	ne					
R	esults	s for	: thruster			
	EnVisio	n Test	> EnVision Test > UI DSM - EnVision - Iterat		^	
	EnVisio	n Test	PRR - Morning > EnVision Test PRR > UI DS	M - EnVision - Iteration 15 - 02/10/2023 14·14·24 Select View	×	^
	EnVisio	n Test	PRR - Afternoon > EnVision Test PRR > UI D	 Functional Breakdown Requirement Traceability To Function Function Traceability To Product 		^



Task 3 – Requirements Compliance

- User Requirements (Total): 221
 - RFD: 8
 - RFW: 29 \rightarrow 25 related to views & concepts considered out of the project scope
- Derived Software Requirements (Total): 226
- RFWs: Agreed through iterative discussion
 - Waive: 21
 - Partially Waive: 22





Validation Exercise



Objectives

- To get user feedbacks and impressions about the prototype
- Evaluate the guidance, usability, usefulness, ... and future improvements
- General plan:
 - 2 sessions: large group and individual interviews
 - Mandatory steps for each participant : briefing, use of the tool (exploration and guided exercises), debriefing.
- Data collected:
 - Users feedback and comments
 - SUS questionnaire results
 - Interview reports
 - Observations (unconscious behaviours, mistakes, way of finding things, frustrations, etc...)



Scenario (example)

- Based on the user journeys and depending on participants domain of expertise
- Navigate through every major viewpoints and functionalities of the prototype

Domain	User journey	Task	Question	Expected answer	Viewpoint	Main features
	UJ1: Check the requirements completeness	PRR2 – Do completeness check.	Is there any Communications requirement derived from the System or Mission Requirements? Leave a Comment stating that you do not agree with the Requirement flow-down.	Only 1, COM-040	Requirement Traceability To Requirement	Filter Column View Setting Comment
Communications	UJ2: Check the requirements functional allocation completeness	PRR3 – check requirements are allocated to functions adequately	1-Find how many functions are fulfilled by the communications subsystem. (Tip: Use the global search bar)2-Which Communication requirements do not have a function which satisfies them?	8 COM-010, COM-030, COM-040	Requirement Traceability To function	Filter Column View Setting Search Option switch
	UJ3: Check the function to physical allocation completeness and adequateness	PRR3 – Check function allocation to products.	 1-Do all the functions fulfilled by the communications subsystem have a product which implements them? 2-From the Products owned by the Communications expert, which ones have a technology identified? (Tip: click in settings → show technology) Is that linked to the TRL value? Which is this value? Mark the product "As Reviewed" 	Yes Transponders, TRL=4	Function Traceability To Product Product Breakdown	Filter Column View Setting Related view Context info panel Mark as reviewed
	UJ4: Check the mass budget review	PRR3 – Check budget	What is the model mass of the "High Gain Antenna"?	33	Budget	Search in budget
	UJ5: Check the architecture interfaces consistency and completeness.		1-Open an architecture diagram, open a saved configuration (System Architecture) and Leave a comment in the TM/TC Interface to the Ground Stations. (e.g. ask for details on frequency band) 2-Look for the High Gain Antenna in the Interfaces list. (tip: in settings, select definition by product). Select it and open an architecture diagram. Expand the diagram by double clicking on components. Can you check if the connections between Comms components and the transponders are properly modelled? Leave a comment in one of the interfaces.		Interfaces Architecture Diagram	Filter Diagram configuration Comment

• The last three columns are not provided to the participants.







Results

• The UI DSM app the interface layout less cluttered and the data models easier to understand







Conclusions

- 1. The Web environment and its UI features indeed improve the user experience in navigating and reviewing an MBSE model.
- 2. Support for Novice MBSE users is not always experienced useful by Experts.
- 3. To enable the interlinked nature of the web environment, the rigour of the model has to be improved beyond current standards.
- 4. To support (collaborative) reviewing, review management and enhanced collaboration features are an important additional feature.
- 5. There is a key challenge still in creating automated diagramming that is intuitive and helps novices in reducing complexity.







Key improvements:

- Enhancing review management features.
- Enhancing guidance and navigation
- Enhancing diagramming.
- Enhancing flexibility, offering guidance without creating restrictions for novice and advance users alike.
- Lifecycle support, connecting the interface to the MBSE Hub and enable more review and monitoring tasks throughout the lifecycle.
- Improved search results
- Revisiting 3D model integration



Roadmap - Future Work

					Qtr 3, 20	023		Qtr 4, 2	023		Qtr 1, 2	024		Qtr 2, 2	024		Qtr 3, 2	024		Qtr 4, 20)24	
	Task Name	Start 🗸	Finish 👻	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Identification of new use cases and user needs	Thu 01/06/23	Mon 28/08/23	· · · · ·																		
2	Assessment of User needs for other mission phases	Thu 01/06/23	Fri 14/07/23																			
3	Evaluate and select potential domain specific tools to extract information from for reviews	Thu 01/06/23	Fri 14/07/23																			
4	Identify data sources and gather example data	Tue 27/06/23	Tue 01/08/23	9		h I																
5	Define new use cases	Wed 02/08/23	Fri 18/08/23			t																
6	Identify specific features missing in first prototype	Mon 21/08/23	Mon 28/08/23			1																
7	Tool selection and architecture design	Tue 29/08/23	Tue 31/10/23			ŕ			η													
8	Explore and select new state-of-the-art solutions	Tue 29/08/23	Fri 29/09/23																			
9	Architecture design	Mon 02/10/23	Mon 16/10/23																			
10	Consolidate UI/UX design	Mon 02/10/23	Mon 23/10/23																			
11	Defintion of Requirements	Mon 16/10/23	Tue 31/10/23					+														
12	4 Development	Wed 01/11/23	Mon 29/04/24					1	<u>+</u>						η							
13	Development of the new tool	Wed 01/11/23	Mon 29/04/24																			
14	Creation of additional MBSE models to support development and testing	Mon 18/12/23	Wed 31/01/24																			
15	Creation of documenttion and tutorials	Mon 01/04/24	Mon 29/04/24																			
16	Validation Exercises	Tue 30/04/24	Fri 21/06/24											i	+							
17	Prepare Evaluation and Deployment	Tue 30/04/24	Fri 10/05/24												-n							
18	Individual Evaluation	Mon 13/05/24	Fri 17/05/24												_*⊢							
19	Concurrent Evaluation	Mon 20/05/24	Fri 24/05/24												1							
20	Process Evaluation Results and Determine needed updates	Mon 27/05/24	Fri 21/06/24												1							
21	Updates and Deployment	Mon 24/06/24	Fri 30/08/24													Ť			η			
22	Perform required software updates	Mon 24/06/24	Mon 22/07/24														h					
23	Training of review managers	Tue 23/07/24	Fri 30/08/24														1					
24	Deployment	Tue 23/07/24	Fri 30/08/24														+					
25	Use of the tool in a real review process	Mon 02/09/24	Fri 25/10/24																t—			
26	Introduction, training, and preparation of the review	Mon 02/09/24	Mon 23/09/24																			
27	Support the Review and gather feedback	Tue 24/09/24	Fri 25/10/24																+			
28	Software Updates	Mon 28/10/24	Fri 29/11/24																	t		η
29	Process feddback from Review Process	Mon 28/10/24	Fri 15/11/24																			
30	Perform software updates	Mon 11/11/24	Fri 29/11/24																			
31	Activity Consolidation	Mon 02/12/24	Fri 13/12/24																			t-i
32	Activity Consolidation	Mon 02/12/24	Fri 13/12/24																			





hdc Human Design Group

Roadmap steps

• Revise analysis

- Broaden scope
- Refine experiences from prototype
- Observe/analyse real life collaborative review
- Include research topics identified
- Tool selection and architecture design
- Development
- Evaluation
 - Concurrent
 - Broader user audience
 - Real Review scenario
- Updates and conclusions













