An iterative approach for model-based requirements engineering in large collaborative projects: A detailed experience report

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[1]

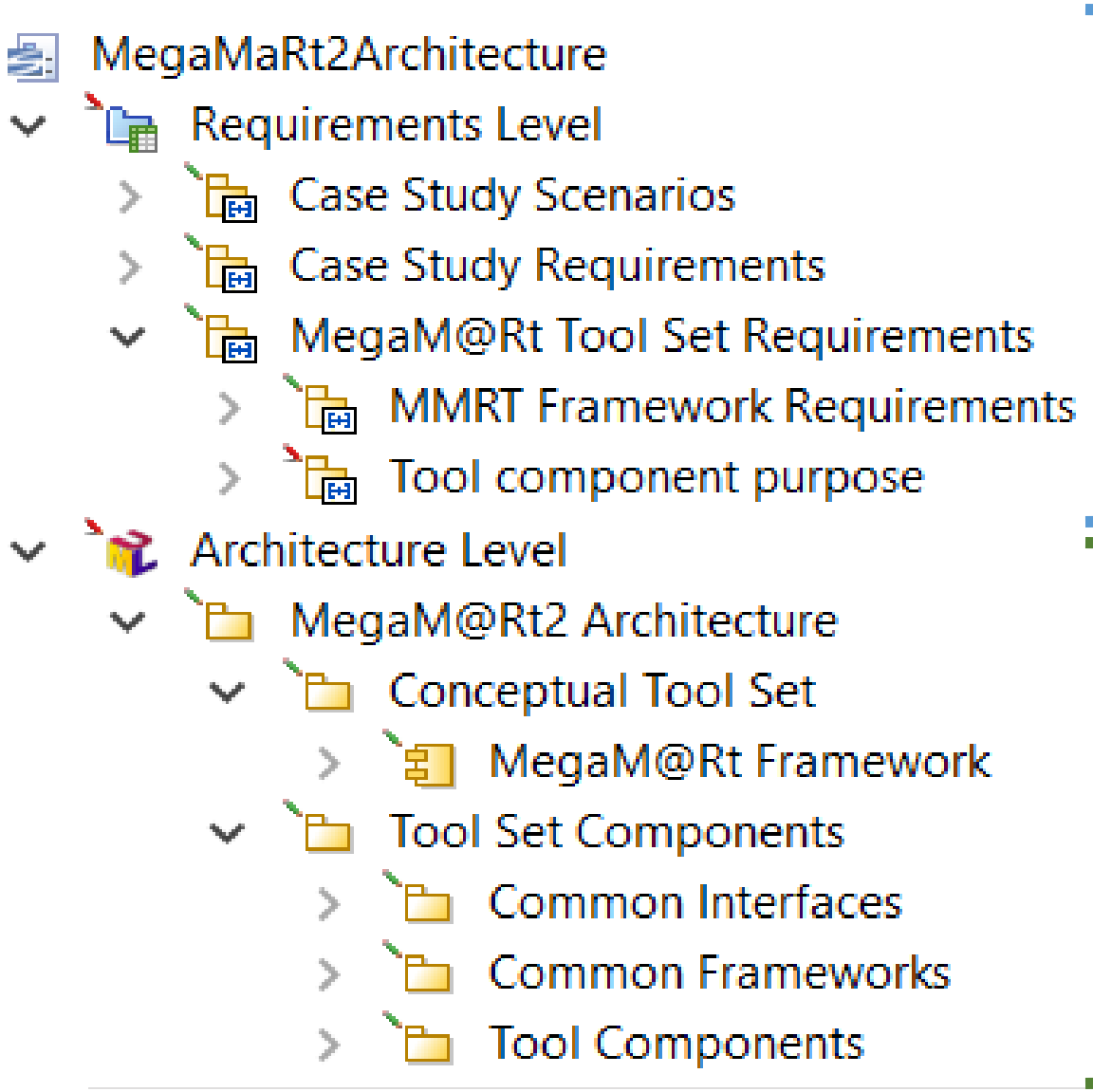
Context

- European research projects (ECSEL, Horizon Europe, Celtic, ITEA) with many partners
  - 30-40 on average in some projects
- Diversity of partners (-> good for complementarity):
  - Background
  - Size
  - Application domain
- Interest (technology developer, technology adopter, research)
- Technical level
- Academic vs industrial
- Challenges:
  - Elicitation of needs for technology adopters in different domains
  - Identification of technical solutions per partner
  - Development and evaluation roadmap planning

Example, Collaboration, Complementarities and Differences (MegaM@Rt project)

		Case study providers									Technology providers (Tools and Methods)																
		TRT	CSY	IKER	TEK	NOK	VCE	BT	CAM	AINA	SOFT	SMA	ARM	UPAU	ATOS	UCAN	UOC	FTS	UAQ	INT	RO	ABO	SSF	VTT	CON	MDH	SICS	BUT
Application Domain	Transportation	x	x				x	x	x		Modelio suite	Smartesting Tools (CertifyIt / MBeetle)	AM3, EMFViews, Neo4EMF, ATL	Model execution (PauWare, SCXML)	EMF, ATL, Acceleo, OCL, UML2, Profiles		EMFtoCSP, Collaboro		EMF, MOSES, ATL, Acceleo, MARTE, UML2	CHESS (Modeling) & MOSES (Performance Analysis)	Completeness/Consistency Requirements check		LIME toolset		rmiq De			
	Smart warehouse			x																							
	Telecom				x	x				x																	
	Industrial Control			x					x																		
Innovation topics	Domain specific languages	x	x			x			x		x	x	x	x	x	x	x					x						x
	Requirements modeling	x			x	x	x	x			x					x		x		x	x					x		
	Aspect oriented modeling	x									x				x							x						x
	MB Verification	x	x			x	x	x		x					x	x	x	x		x	x	x				x	x	x
	MB Performance Analysis				x					x						x			x	x								
	Simulation	x		x	x	x		x						x		x										x		
	MB Validation	x	x			x	x	x		x		x			x		x	x	x			x			x	x	x	
	(MB) Runtime verification	x		x	x	x	x	x	x	x				x								x	x	x		x	x	x
	MB testing (online &offline)			x	x	x	x	x	x	x		x				x						x	x		x	x	x	x
	Requirements/system traceability			x		x	x	x			x		x			x		x		x		x			x	x		
	MB collaboration and governance						x	x			x		x				x	x										
	Continuous Development			x	x	x				x	x	x	x	x	x	x		x				x	x	x				x
	Anti-pattern detection	x													x		x		x									
	Root-cause analysis					x	x	x		x													x	x		x	x	
	Model Management & Storage					x					x		x					x	x									

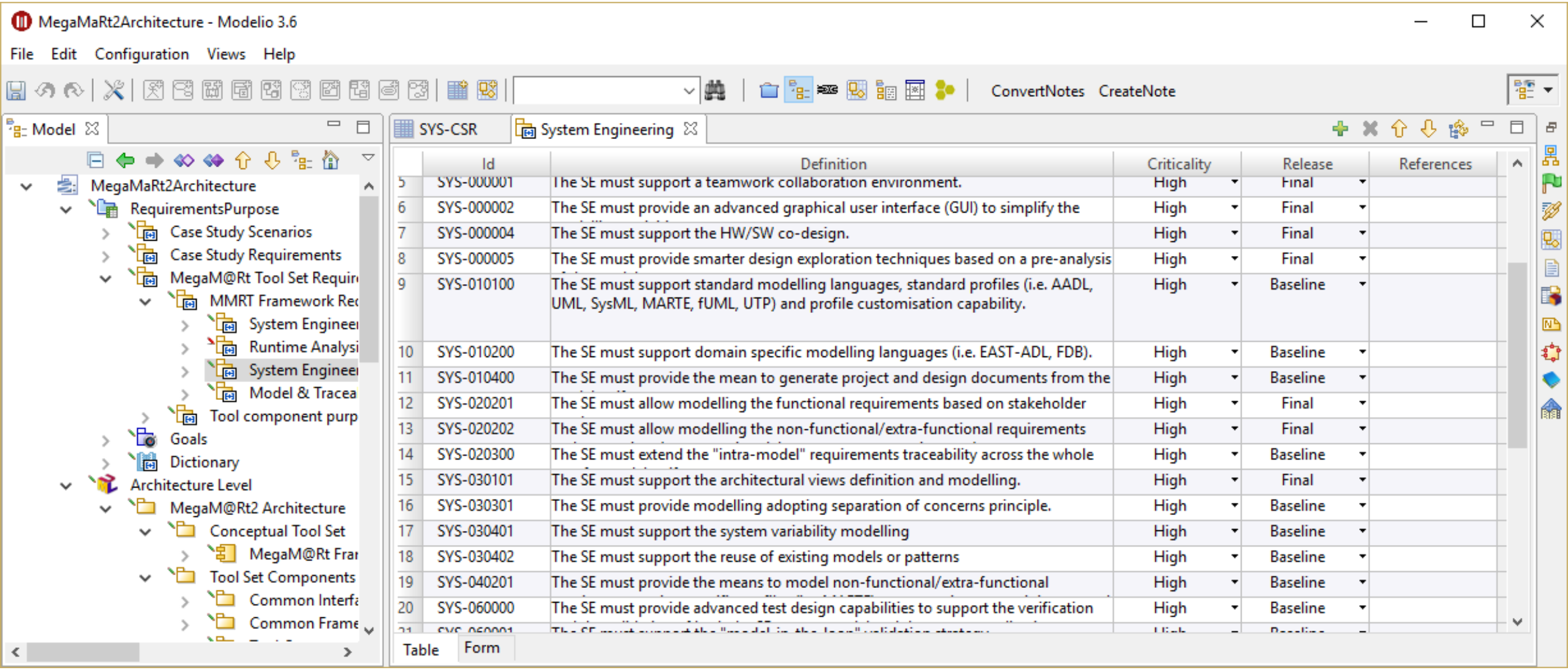
Model structure (MegaM@Rt project)



Textual Requirements

Notional Architecture

Framework requirements (MegaM@Rt project)



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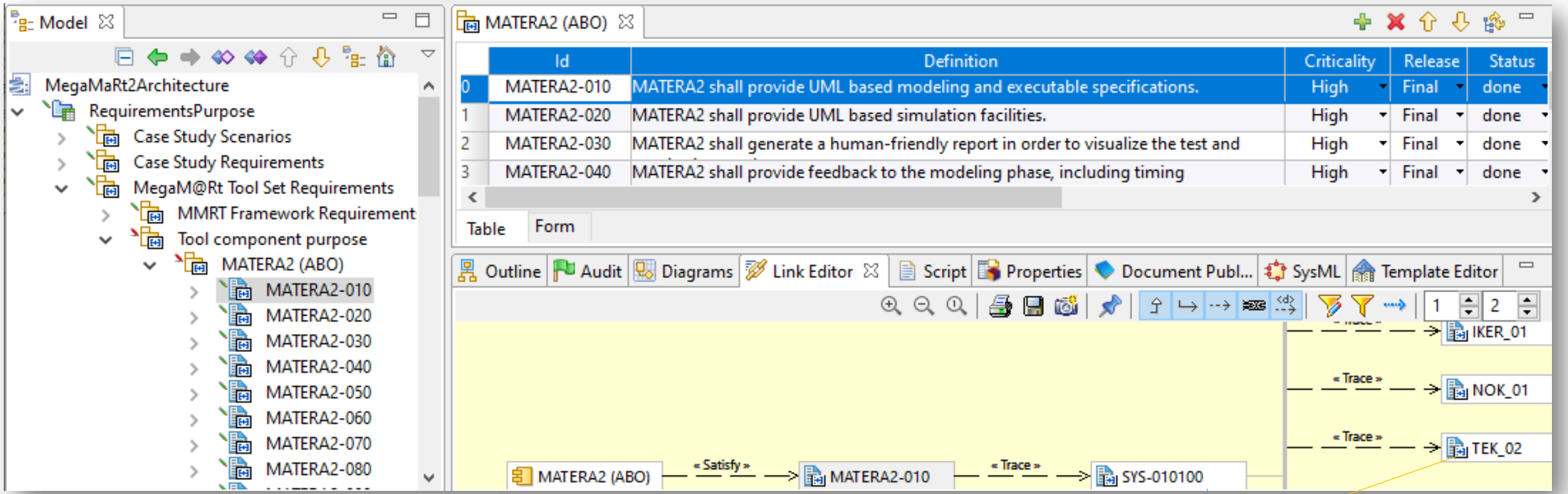
Tool components requirements and traceability



Tool component

Tool Requirement

Framework Requirement

Case Study Requirements

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Roadmap example (MegaM@Rt project)

time

Framework Requirements

Framework Features	Baseline	Initial	Intermediate	Final
	110			
RTA-00006: The framework shall provide requirement traceability facilities at runtime	CERTIFYIT-110 CQDESIGN-060	JTL-050 [done]	JTL-030 [in progress] JTL-040 [in progress] MBEETLE-090 MBEETLE-110	MATERA2-090 MBEETLE-100
RTA-00007: Trace monitoring and online testing at runtime shall improve trace analysis results and localization of faults	AIPHS-010 AIPHS-020 AIPHS-030 CERTIFYIT-080 CERTIFYIT-090		MBEETLE-090	AIPHS-060 [planned] COMPTEST-030
RTA-00008: Trace monitoring and online testing shall be combined at runtime to verify functional as well as non-functional properties in a synergic way	MATERA2-070 AIPHS-010 AIPHS-020 AIPHS-030	LIME-010 [done]		MBEETLE-010 [in progress] COMPTEST-030
RTA-00009: Trace analysis tools shall be able to collect and analyse information from different sources and using different techniques				JTL-060 PADRE-060 [planned]

Tool Requirement

Generated documents (MegaM@Rt project)

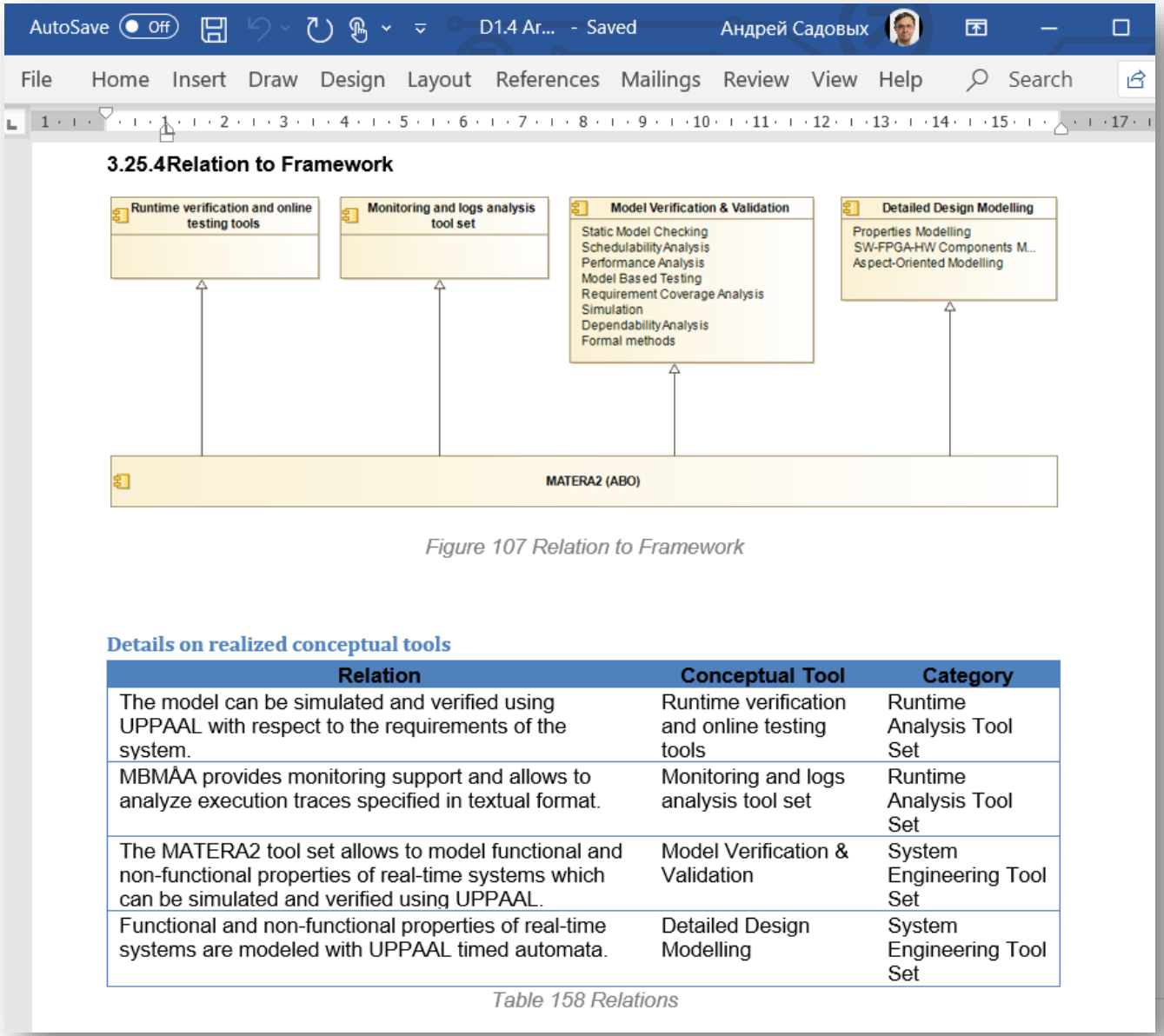

Figure 107 Relation to Framework

Details on realized conceptual tools

Relation	Conceptual Tool	Category
The model can be simulated and verified using UPPAAL with respect to the requirements of the system.	Runtime verification and online testing tools	Runtime Analysis Tool Set
MBMÅA provides monitoring support and allows to analyze execution traces specified in textual format.	Monitoring and logs analysis tool set	Runtime Analysis Tool Set
The MATERA2 tool set allows to model functional and non-functional properties of real-time systems which can be simulated and verified using UPPAAL.	Model Verification & Validation	System Engineering Tool Set
Functional and non-functional properties of real-time systems are modeled with UPPAAL timed automata.	Detailed Design Modelling	System Engineering Tool Set

Table 158 Relations

- Live document
- Unified project document style
- In sync with Requirements and Architecture changes
- Submitted as a project deliverables with minor polishing

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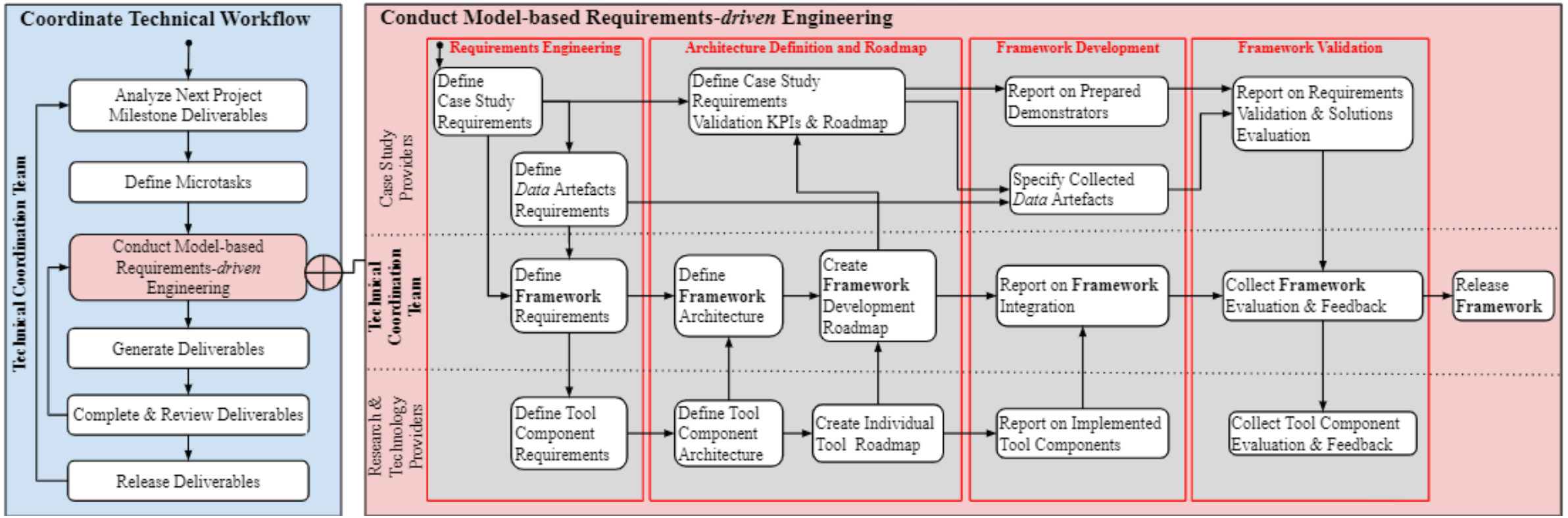
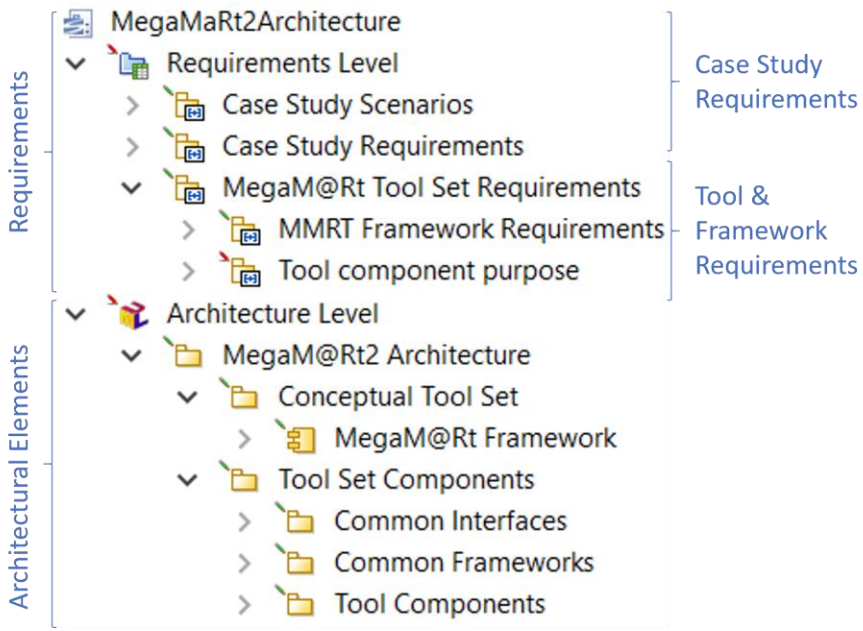
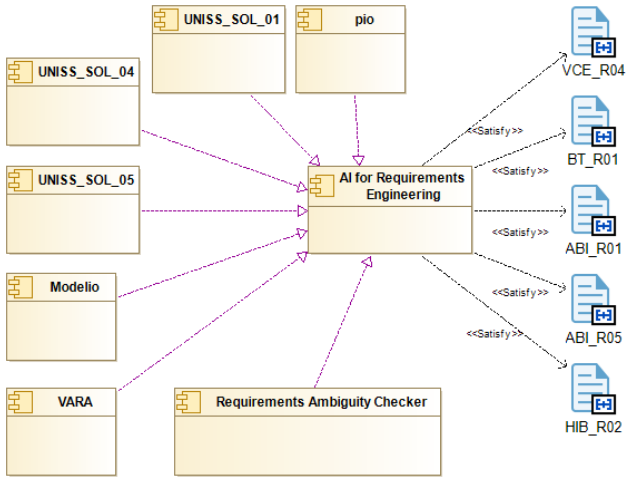
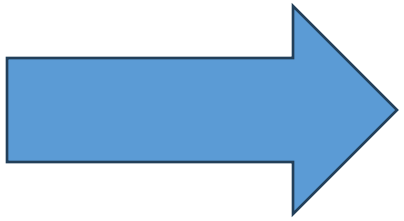
7 years, 5 collaborative projects, 100s engineers, MBRE

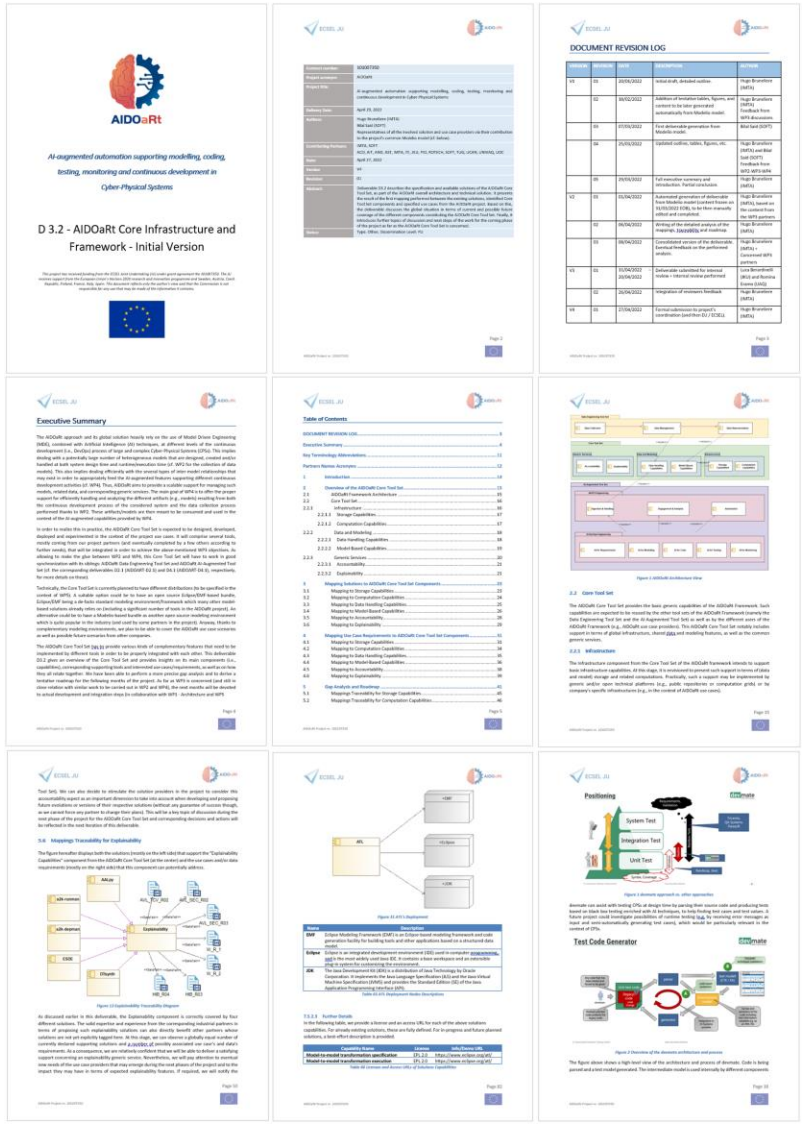


Tool support: modelling, analysis, documents









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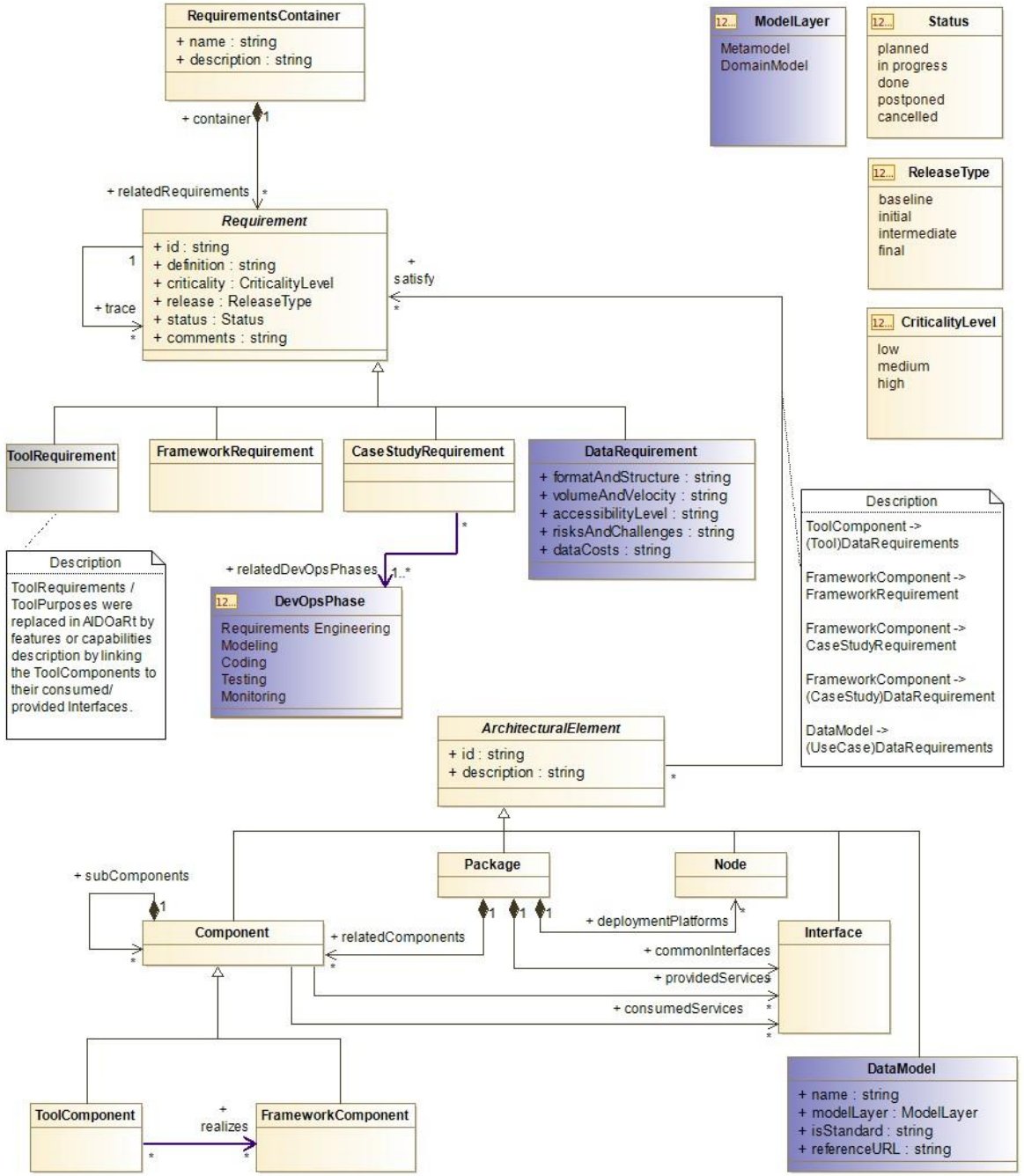
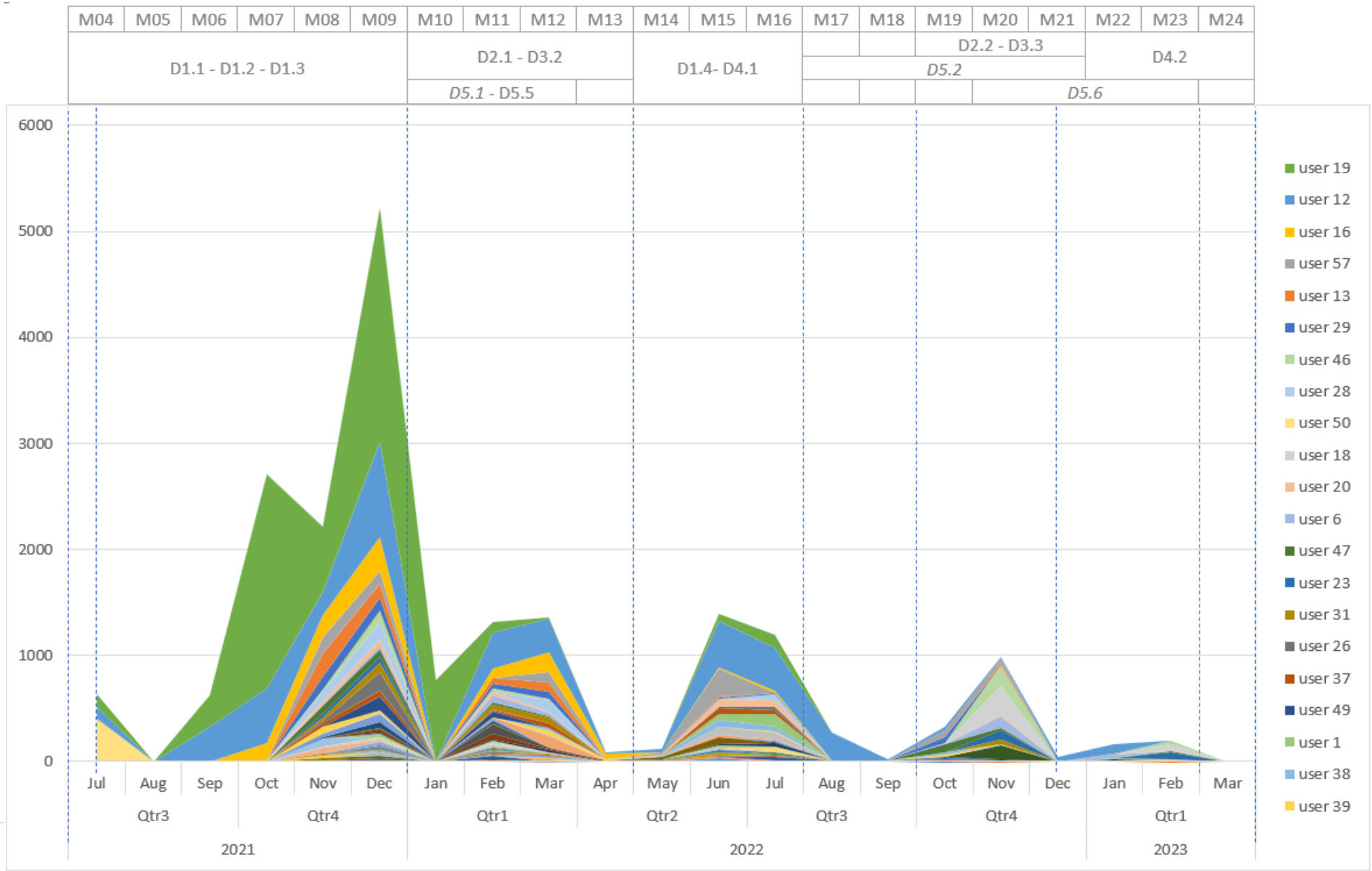
Extended Metamodel (AIDOaRt)



Modelling scale

Number of	DataBio	REVaMP2	MegaM@Rt2	VeriDevOps*	AIDOaRt*
Partners	48	27	27	7	31
Countries	17	5	6	4	7
Case studies	27	7	9	2	15
Project months	36	36	36	36	36
Registered users	55	43	56	15	100
Contributors	31 (56%)	24 (56%)	27 (48 %)	7 (47%)	60 (60%)
Commits	958	534	1322	328	2548
Requirements:	=181	=535	=428	=124	=455
(Case Study r.	77	190	106	39	363
+ Framework r.	104	56	91	NA$	17
+ Tool r.)	NA#	289	231	85	75
Model elements†	=5406	=3307	=4744	=2087	=9512
(Requirements	535	1091	2351	1211	3507
+ Architecture)	4871	2216	2393	876	6005
Pages generated	61	109	125	120	~160 x 11‡

Modelling intensity over the time



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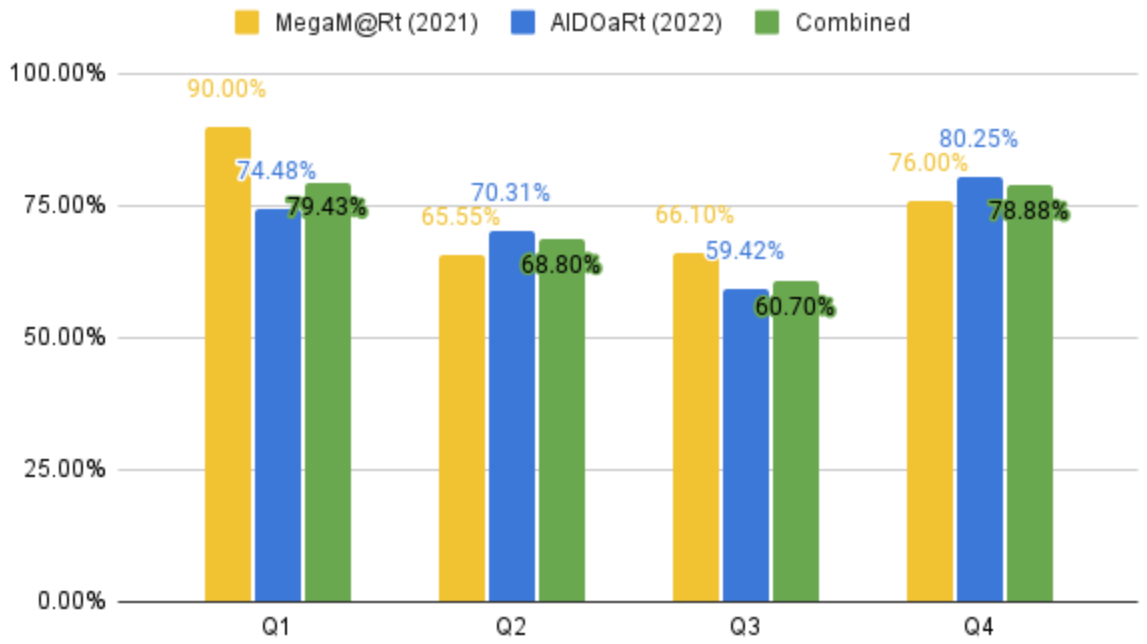
46 project participants. Overall positive feedback

- Q1: In your opinion, did you find this graphical model-based approach useful in different activities of Requirements Engineering?
- Q2: In your opinion, do you see the modeling approach as an improvement compared to other non-modeling(e.g., text-only or table-based)regarding the following aspects?
- Q3: In your opinion, did you find the following Modelio tool features useful in different Requirements Engineering activities?
- Q4: Please indicate your opinion on the implementation of the MBRE approach using Modelio.



Overall assessment

Lessons

- Model as a common language
- Project Planning
- Framework Architecture
- Language and Model Complexity
- Learning Curve
- MBRE and Collaboration

Challenges

- From Requirements to Source Code
- User Training and Support
- Collaborative and Online Model Editing
- Automation and Production-Readiness

Demonstrated

- Scalability
- Heterogeneity
- Adaptability and Extensibility
- Traceability
- Automation
- Consistency and Quality
- Usefulness and Usability

Thank you for your attention

Questions?

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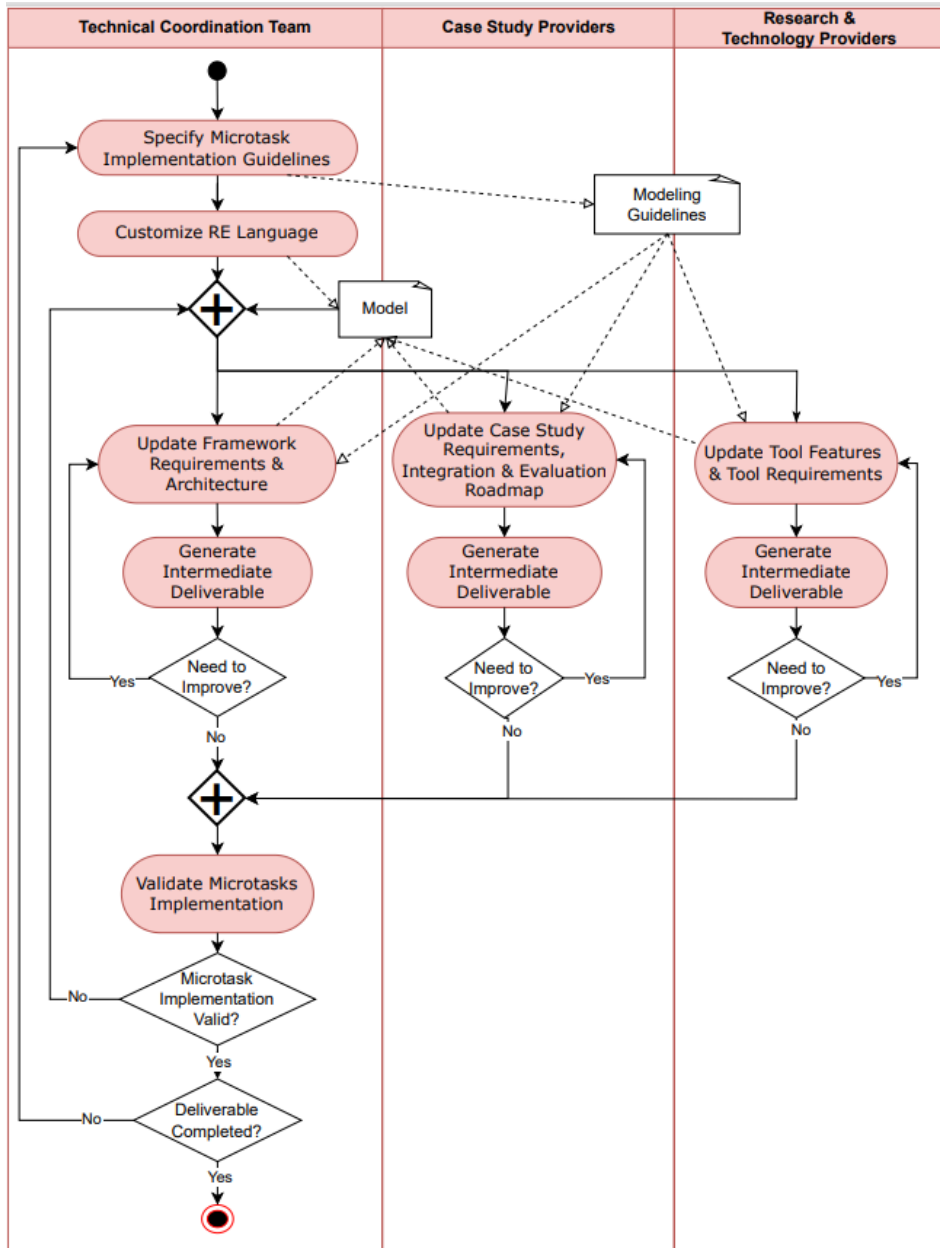
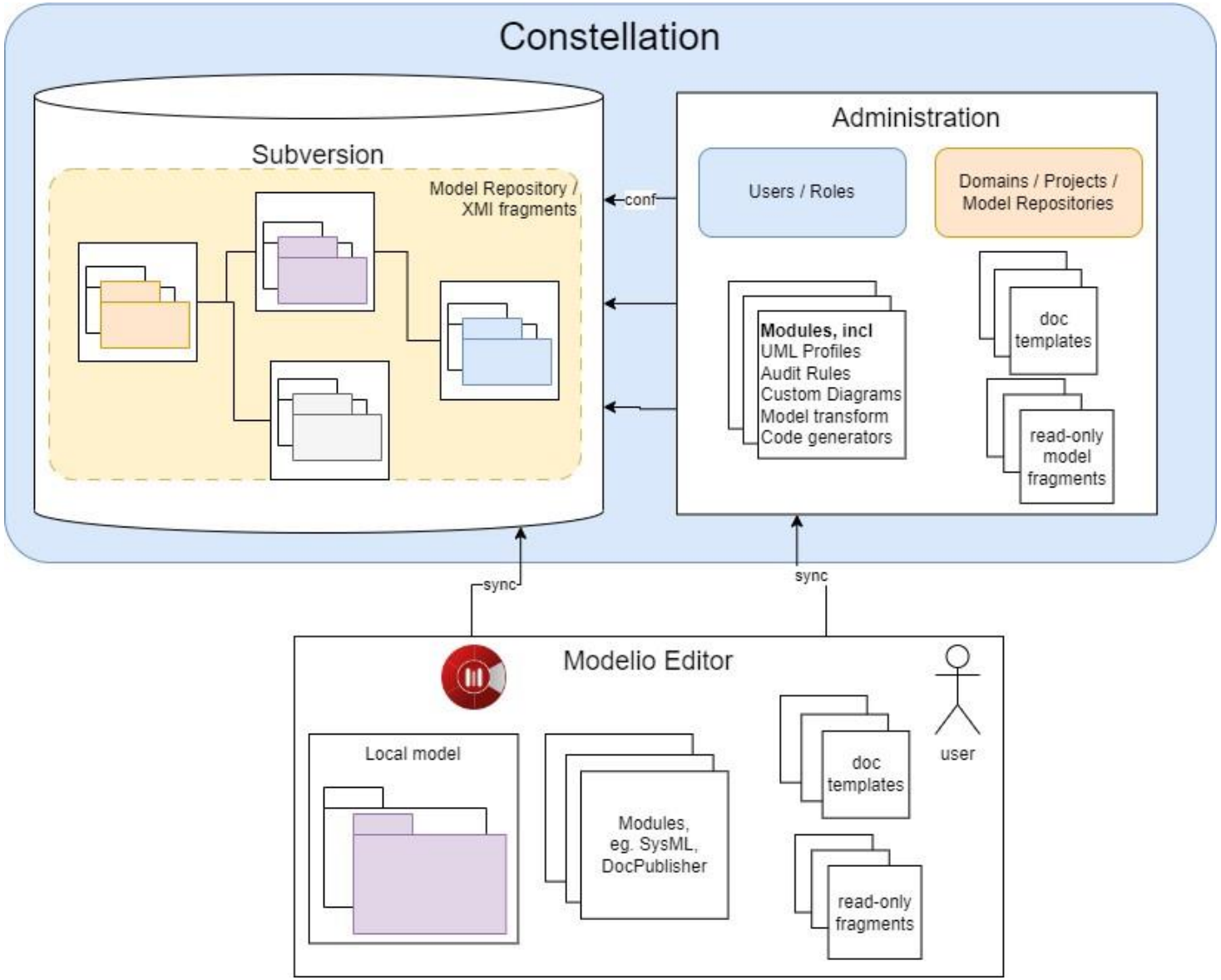
Micro-tasks



Implementation



VeriDevOps - automating security requirements verification in DevOps