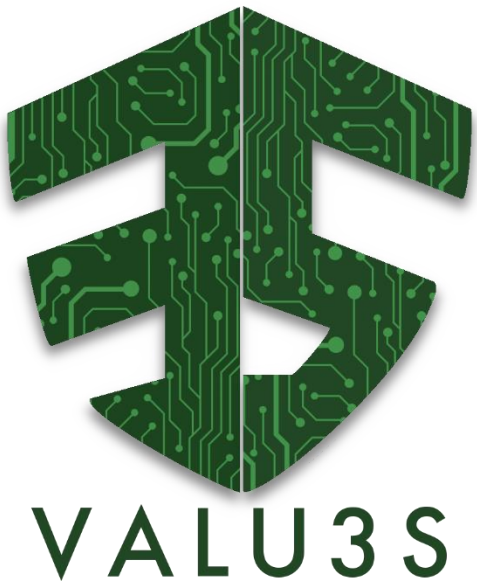

Verification and Validation of Automated Systems' Safety and Security

Final Exploitation Activity Report and Short/Long Term Market Analysis

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Disclaimer

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Project Overview

Manufacturers of automated systems and the manufacturers of the components used in these systems have been allocating an enormous amount of time and effort in the past years developing and conducting research on automated systems. The effort spent has resulted in the availability of prototypes demonstrating new capabilities as well as the introduction of such systems to the market within different domains. Manufacturers of these systems need to make sure that the systems function in the intended way and according to specifications which is not a trivial task as system complexity rises dramatically the more integrated and interconnected these systems become with the addition of automated functionality and features to them.

With rising complexity, unknown emerging properties of the system may come to the surface making it necessary to conduct thorough verification and validation (V&V) of these systems. Through the V&V of automated systems, the manufacturers of these systems are able to ensure safe, secure and reliable systems for society to use since failures in highly automated systems can be catastrophic.

The high complexity of automated systems incurs an overhead on the V&V process making it time-consuming and costly. VALU3S aims to design, implement and evaluate state-of-the-art V&V methods and tools in order to reduce the time and cost needed to verify and validate automated systems with respect to safety, cybersecurity and privacy (SCP) requirements. This will ensure that European manufacturers of automated systems remain competitive and that they remain world leaders. To this end, a multi-domain framework is designed and evaluated with the aim to create a clear structure around the components and elements needed to conduct V&V process through identification and classification of evaluation methods, tools, environments and concepts that are needed to verify and validate automated systems with respect to SCP requirements.

In VALU3S, 13 use cases with specific safety, security and privacy requirements will be studied in detail. Several state-of-the-art V&V methods will be investigated and further enhanced in addition to implementing new methods aiming for reducing the time and cost needed to conduct V&V of automated systems. The V&V methods investigated are then used to design improved process workflows for V&V of automated systems. Several tools will be implemented supporting the improved processes which are evaluated by qualification and quantification of safety, security and privacy as well as other evaluation criteria using demonstrators. VALU3S will also influence the development of safety, security and privacy standards through an active participation in related standardisation groups. VALU3S will provide guidelines to the testing community including engineers and researchers on how the V&V of automated systems could be improved considering the cost, time and effort of conducting the tests.

VALU3S brings together a consortium with partners from 10 different countries, with a mix of *industrial partners* (25 partners) from automotive, agriculture, railway, healthcare, aerospace and industrial automation and robotics domains as well as leading *research institutes* (6 partners) and *universities* (10 partners) to reach the project goal.

Consortium

RISE RESEARCH INSTITUTES OF SWEDEN AB	RISE	Sweden
STAM SRL	STAM	Italy
FONDAZIONE BRUNO KESSLER	FBK	Italy
KNOWLEDGE CENTRIC SOLUTIONS SL - THE REUSE COMPANY	TRC	Spain
UNIVERSITA DEGLI STUDI DELL'AQUILA	UNIVAQ	Italy
INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO	ISEP	Portugal
UNIVERSITA DEGLI STUDI DI GENOVA	UNIGE	Italy
CAMEA, spol. s r.o.	CAMEA	Czech
IKERLAN S. COOP	IKER	Spain
R G B MEDICAL DEVICES SA	RGB	Spain
UNIVERSIDADE DE COIMBRA	COIMBRA	Portugal
VYSOKE UCENI TECHNICKE V BRNE - BRNO UNIVERSITY OF TECHNOLOGY	BUT	Czech
ROBOAUTO S.R.O.	ROBO	Czech
ESKISEHIR OSMANGAZI UNIVERSITESI	ESOGU	Turkey
KUNGLIGA TEKNISKA HOEGSKOLAN	KTH	Sweden
STATENS VAG- OCH TRANSPORTFORSKNINGSINSTITUT	VTI	Sweden
UNIVERSIDAD DE CASTILLA - LA MANCHA	UCLM	Spain
FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	FRAUNHOFER	Germany
SIEMENS AKTIENGESELLSCHAFT OESTERREICH	SIEMENS	Austria
RULEX INNOVATION LABS SRL	RULEX	Italy
NXP SEMICONDUCTORS GERMANY GMBH	NXP-DE	Germany
PUMACY TECHNOLOGIES AG	PUMACY	Germany
UNITED TECHNOLOGIES RESEARCH CENTRE IRELAND, LIMITED	UTRCI	Ireland
NATIONAL UNIVERSITY OF IRELAND MAYNOOTH	NUIM	Ireland
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ERGUNLER INSAAT PETROL URUNLERI OTOMOTIV TEKSTIL MADENCILIK SU URUNLER SANAYI VE TICARET LIMITED STI.	ERARGE	Turkey
OTOKAR OTOMOTIV VE SAVUNMA SANAYI AS - OTOKAR AS	OTOKAR	Turkey
TECHY BILISIM TEKNOLOJILERI DANISMANLIK SANAYI VE TICARET LIMITED SIRKETI - TECHY INFORMATION TECHNOLOGIESAND CONSULTANCY LIMITED COMPANY	TECHY	Turkey
ELECTROTECNICA ALAVESA SL	ALDAKIN	Spain
INTECS SOLUTIONS SPA	INTECS	Italy
LIEBERLIEBER SOFTWARE GMBH	LLSG	Austria
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH	AIT	Austria
E.S.T.E. SRL	ESTE	Italy
NXP SEMICONDUCTORS FRANCE SAS	NXP-FR	France
BOMBARDIER TRANSPORTATION SWEDEN AB	BT	Sweden
QRTECH AKTIEBOLAG	QRTECH	Sweden
CAF SIGNALLING S.L	CAF	Spain
MONDRAGON GOI ESKOLA POLITEKNIKOA JOSE MARIA ARIZMENDIARRIETA S COOP	MGEP	Spain
INFOTIV AB	INFOTIV	Sweden
BERGE CONSULTING AB	BERGE	Sweden
CARDIOID TECHNOLOGIES LDA	CARDIOID	Portugal

Executive Summary

This deliverable (D6.21) is the final exploitation activity report and short/long-term market analysis of VALU3S. It identifies the main exploitation-related activities carried out during the last year of the project and discusses the commitment and responsibilities of the project partners in relation to these activities, represented through specific and continuously monitored KPIs.

This deliverable also examines the different target markets that the results obtained within VALU3S may reach and updates its status with respect to D6.16 [1] based on the current situation of the coronavirus [2], the war in Ukraine [3], and the recent natural disaster in Turkey and Syria [4]. This analysis has been done according to the domain in which they have been developed and the type of organisation that intends to exploit them in order to successfully identify the "smallest viable market" to develop an effective business plan.

Once the project is completed, the VALU3S consortium would like to ensure that the impact of its results lasts over time. Therefore, this document also contains an outline of several initiatives that a group of the consortium has been working on during the project to try to ensure this wish under the motto 'Life after VALU3S'.

Consequently, this deliverable is closely linked to other deliverables in WP6 and other work packages across the project. Below are detailed those WP6 deliverables directly related to this document and when they were delivered.

- D6.4. Initial exploitation plan (Lead Participant: ALDAKIN, due: M4, Dissemination Level: Confidential).
- D6.8. Initial exploitation activity report and short/long-term market analysis (Lead Participant: ALDAKIN, due: M12, Dissemination Level: Public).
- D6.13. Final exploitation plan (Lead Participant: ALDAKIN, due: M18, Dissemination Level: Confidential).
- D6.16. Interim exploitation activity report and short/long-term market analysis (Lead Participant: ALDAKIN, due: M24, Dissemination Level: Public).

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1.1	2023-04-27	Behrooz Sangchoolie (RISE)	Final version of the report to be submitted.

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Acronyms

AI	Artificial Intelligence
ALTA	Latin American and Caribbean Air Transport Association
API	Application Programming Interface
CAGR	Compound Annual Growth Rate
CPS	Cyber Physical System
CSA	Coordination and Support Action
DSL	Domain Specific Language
DTML	Digital Transformation Modelling Language
EA	Enterprise Architecture
EA Repo	Enterprise Architecture Repository
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FO-LTL	First-Order Linear Temporal Logic
GA	Grant Agreement
IPR	Intellectual Property Rights
IoT	Internet of Things
GDP	Gross Domestic Product
HSR	High-Speed Railway
IATA	International Air Transport Association
KER	Key Exploitable Result
KPI	Key Performance Indicator
LRT	Light Rail Transit
MDG	Model Driven Generation
MTL	Metric Temporal Logic
NATO	North Atlantic Treaty Organization
OEM	Original Equipment Manufacturer
PCA	Project Cooperation Agreement
RAR	Russian Association of Robotics
RSI	Rail Supply Industry
RTO	Research Technology Organisation
SCP	Safety, Cybersecurity, and Privacy
SME	Small and Medium-Sized Enterprise
STL	Signal Temporal Logic

TRL	Technology Readiness Level
TIC	Testing, Inspection, and Certification
UAV	Unmanned Aerial Vehicle
UML	Unified Modelling Language
V&V	Verification and Validation
VVML	Verification and Validation Modelling Language
WHO	World Health Organization

Chapter 1 Introduction

As stated in the project proposal, the exploitation objectives of the VALU3S project are the design, implementation, and evaluation of state-of-the-art verification and validation (V&V) methods and tools. The goal is to reduce the time and cost needed to verify and validate automated systems concerning safety, cybersecurity, and privacy (SCP) requirements. Therefore, after the submission of deliverables D6.13 [5] (confidential) and D6.16 [1] (public), this deliverable aims to present the activities conducted around the exploitation of the results during the last year of the project. In addition, it also aims to gather valuable data to facilitate the identification of the most viable target markets. These data contain a generic market analysis for each sector or domain worked on in the project and a specific analysis for each organisation that contributes to that domain. More specifically, the key market drivers and trends, needs and challenges, competitors, and the value proposition of VALU3S with respect to VALU3S partners and stakeholders are identified. Lastly, the document also contains a market risk assessment that provides tools to mitigate potential forecast errors for each of the markets, as well as a proposal on what could be the next lines of action after the end of the project, also called 'Life after VALU3S'.

Overall, the objectives of the deliverable are to:

- Present a report on the exploitation-related actions carried out during the project's last year.
- Introduce the relevant actors and markets in the context of exploitation and highlight the importance of analysing their roles and needs.
- Ensure the entities participating in this task know their target markets to achieve the desired impact.
- Establish a generic market risk assessment that all partners can benefit from to anticipate possible forecast errors in the market.
- Propose future lines of action for the exploitation of the project after its completion.

Almost all partners are involved in the exploitation activity by evaluating the potential use, marketability, and applicability of the key concepts and ideas for the evolution of the methods.

1.1 Intended Readership

This deliverable is a public document that outlines the exploitation activities and market analysis of the VALU3S project. Given its public nature, this document can be disseminated inside and outside the consortium and will, therefore, by publicly accessible.

This document is of special interest to all the partners of the VALU3S project since many associates have committed themselves to contributing and participating in the exploitation activities. This involves evaluating the potential of use, marketability, and applicability of the key concepts and ideas for the evolution of the developed methodologies to generate a set of actions that ensure greater exploitation and impact of the obtained results.

Therefore, this document serves as a tool both for recording and monitoring the activities carried out by the partners around the exploitation of their results and for identifying potential markets where VALU3S results could fit in. Thus, the work involved in preparing this deliverable encourages the partners to analyse their future results in a more business-oriented way.

1.2 Structure of the Deliverable

After this overview, the deliverable is structured as follows:

- **Chapter 2: Objectives and methodology for market analysis**. The second chapter of this deliverable describes the objectives of the market analysis for the project and defines which key performance indicators (KPIs) are needed to measure that these objectives are successfully achieved. It also links these KPIs to the exploitation activities, thus relating the importance of market analysis in any exploitation plan. Finally, the methodology to perform the specific market analysis for each partner is defined. These steps cover the overall identification of the results of each partner, the identification of the market share to be addressed, and the analysis of the key drivers of that market, trends, user profiles, competitors, and stakeholders. Once all these variables have been analysed, each organisation can identify its key exploitable result (KER), i.e., the result with the highest exploitability.
- **Chapter 3: Final exploitation activity report**. This chapter provides a summary of the exploitation activities conducted by the consortium during the last year of the project and provides a pathway for future exploitation actions.
- **Chapter 4: Short/Long term market analysis.** The fourth chapter of the deliverable contains the generic market analyses of each domain worked on in VALU3S. For each of them, a short-term analysis has been carried out on the situation caused by the still present coronavirus [2], the current crisis in Ukraine [3] and the recent earthquakes in Turkey and Syria [4] and how these have impacted the economy of each sector, as well as their corresponding testing and V&V market. A long-term analysis has also been carried out. This includes forecasts for the coming years. For each domain, four markets have been analysed, considering the intentions of the consortium partners. These markets are 1) the European Single Market, 2) European Market of Non-EU Member Countries, and Neighbouring Partner Countries, including Turkey, Israel, and the Balkan countries Serbia and Croatia, 3) Russia and Asia, and 4) Latin America. From each domain, there is a reference to Appendix A, where the specific market analyses for each partner can be found.
- **Chapter 5: Life after VALU3S**. Following on from the pathway for future exploitation actions outlined in Chapter 3, this chapter sets out several initiatives and concerns on how to prevent the overall results of the project from losing their interest and falling into oblivion once VALU3S comes to an end. For this purpose, it gathers which results should be preserved and which tasks should be carried out in order to do so.
- **Chapter 6: Conclusions**. The sixth and last chapter presents the conclusions drawn from this deliverable. In addition, a short insight into what is expected after the completion of the project is provided.

- **Appendix A**: **Partners' Specific market analysis and key exploitable results**. This appendix contains the market analysis of each partner. These analyses are firstly classified according to whether the partner is a use case provider or a use case contributor (small and medium-sized enterprise (SME) or large organisation, research technology organisation (RTO) or university) and then according to its target market: 1) automotive, 2) agriculture, 3) railway, 4) healthcare, 5) aerospace and 6) industrial robotics/automation.
- **Appendix B**: **Life after VALU3S – How to approach the targets and activities**. This appendix includes a set of maintenance and growth aspects for each of the outcomes and tasks defined in Chapter 5.

Chapter 2 Objectives and Methodology for Market Analysis

This section explains how VALU3S defines the relationship between its exploitation plan and the need for proper market analysis. It also addresses the methodology used to carry out this final market analysis.

2.1 Objectives and Established KPIs

This subsection identifies the objectives to be met within the market analysis and the KPIs defined to successfully exploit the results obtained from the project.

2.1.1 Objectives

In general, the main objective of market analysis is to explore the market to find out the current market situation in terms of existing products and/or services and their current trends, as well as in terms of market potential. Market analysis is crucial to identify and address the most specific market segment possible. A reasonable offer should be in line with the factual (but, in most cases, dynamic) market situation and the subjective needs and preferences of potential users and stakeholders. Therefore, taking all this into account, the specific objectives of this deliverable are:

- To outline each target market and understand their key market drivers, considering barriers and opportunities and market trends.
- To identify the market share and, therefore, who our competitors will be and their value proposition.
- To identify the users' profiles, their preferences and needs, and how to address possible challenges in meeting them.
- To identify the main stakeholders and their value chains and understand their decision-making process.

These objectives have been established to gather the most relevant information to support the exploitation of the results that will be obtained after the completion of VALU3S, i.e., the products resulting from the use cases and the services, packages, or licenses offered around the methodologies and tools for the V&V of different systems.

2.1.2 Established KPIs

In order to support the identification of the KERs of each of the entities of the consortium and to establish the basis for a successful business model and marketing plan, certain specific KPIs related to the exploitation were defined. Table 2.1 shows these KPIs, their initial expected target, the updated targets, and their current values.

Table 2.1. Project exploitation KPIs.

KPI	Description	Initial Target	Updated Target	Current Value
Exp-KPI-1. Patents requested	The objective of this KPI is to promote the patentability of technologies developed to protect intellectual property.	≥ 5	≥ 7	1
Exp-KPI-2. Beta testing agreements	Beta testing is when the system is already functional, but not yet fully completed, with bugs of various kinds or features yet to be implemented and goes into a real environment. It is performed by a subset of end-users and aims to identify undetected problems and correct them before a final version is released. Such testing/demonstrations, e.g., at the premises of a (potential) customer may generate some interest leading to the commercialisation of the technology to the beta tester.	≥ 45	≥ 48	15
Exp-KPI-3. (Potential) agreements with early customers or stakeholders	This KPI aims to encourage partners to seek external customers interested in acquiring the results obtained in VALU3S once the project has been completed and/or the technologies have reached the necessary level of maturity. These agreements could be to purchase licenses, products, training, courses, etc. Potential stakeholders will also be met to seek agreements to enable the global market approach. These stakeholders include suppliers, commercialisation partners (overseas representatives), funding partners, and alliances with actors covering other aspects of the value chain.	≥ 25	≥ 25	15
Exp-KPI-4. Teaching and academic education activities	This KPI aims to determine the number of master theses and PhDs and other types of education and training courses that can be carried out within the framework of VALU3S.	≥ 20	≥ 20	46
Exp-KPI-5. Traders recruited	Another indicator that the exploitation of the technology is succeeding is the need to hire a trader. Some organisations may have such a profile in their staff and will only need to add the developments made in the project to his/her portfolio, while other entities may need to consider hiring one.	≥ 1	≥ 3	4
Exp-KPI-6. Spin-offs created	Many institutions sometimes take the strategic decision to centralise part of their activity independently. This KPI aims to quantify how many spin-offs will be created from the developments made within VALU3S.	≥ 4	≥ 5	0
Exp-KPI-7. Web repository visits	Directly linked to the project's final, this KPI aims to quantify the number of visits the web repository will receive and the number of times it will be used to support V&V tasks outside VALU3S. This KPI will start to be monitored through web analytics tools six months before the end of the project, when the web repository will be made public.	≥ 50	≥ 200	732

The initial quantitative values were collected through a survey shared with the consortium partners during the project's first year and updated for a second time at the beginning of the second year. This was motivated by the fact that some partners were uncertain about the maturity level of their final results, so their exploitation at the beginning of the project was unclear. Also, the values of these indicators have been periodically followed up using similar forms. Although some KPIs have not reached the target set during the project, it should be noted that these indicators are expected to be achieved between one and five years after the end of VALU3S. Much of the outcomes' exploitation will occur after the project's end. Therefore, it is understandable that many of these KPIs will be reached months or even years after VALU3S completion.

2.2 Mapping between Market Analysis and Exploitation Plan

Market analysis is an essential step in defining an effective exploitation plan. Therefore, both concepts are closely linked. Table 2.2 shows the relationship between the KPIs mentioned in Table 2.1 and the partners' exploitation activities (see Subsection 3.1.3).

Table 2.2. Relation between KPIs and exploitation actions.

Actions \ KPI	Exp-KPI-1. Patents requested	Exp-KPI-2. Beta testing agreements	Exp-KPI-3. (Potential) agreements with early customers or stakeholders	Exp-KPI-4. Teaching and academic education activities	Exp-KPI-5. Traders recruited	Exp-KPI-6. Spin offs created	Exp-KPI-7. Web repository visits
A1. Focus on the main results and their commercial viability.			X		X	X	X
A2. Consider new business and operating models for bringing the project results to customers.						X	
A3. Put a strong focus on how stakeholders can profit from the exploitation of the results.			X				
A4. Develop a timeline for exploitation. Identify the prospective time frame after the end of the project to bring the results to the market.					X		
A5. Identify concrete customers' needs and describe ways to quantitatively measure the success.		X	X				
A6. Involve marketing, product-management, and sales departments early in the process.					X		
A7. Start exploitation of intermediate results already during the project.		X	X				

Actions / KPI	Exp-KPI-1. Patents requested	Exp-KPI-2. Beta testing agreements	Exp-KPI-3. (Potential) agreements with early customers or stakeholders	Exp-KPI-4. Teaching and academic education activities	Exp-KPI-5. Traders recruited	Exp-KPI-6. Spin offs created	Exp-KPI-7. Web repository visits
A8. Consider non-technical developments (legal aspects, privacy aspects, etc.) and their influence on exploitation.		X	X				
A9. Protect intellectual property.	X						
A10. Offer seminars, lectures, courses, and the-like with topics related to the project.				X			
A11. Acquire new projects and research related to the present project for further funding.				X			
A12. Ensure that students gain valuable knowledge by their work in the project, which they will take to industry.				X			

2.3 Market Analysis Methodology

The VALU3S market analysis methodology is structured in a multi-step process, as shown in Figure 2.1. This process aims to support partners in the market analysis outlined in this document. Almost all partners actively participate in the process and contribute to its application.

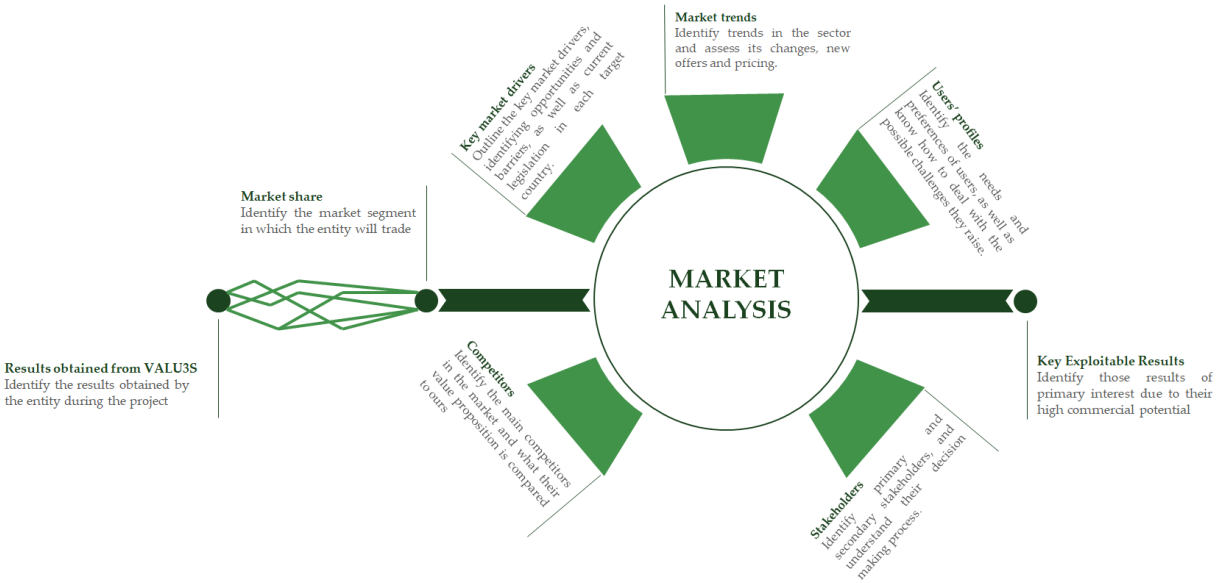


Figure 2.1. VALU3S market analysis methodology.

Firstly, some notes regarding the market analysis. Since the VALU3S project comprises a consortium from 10 countries and diverse entities, including SMEs, large organisations, RTOs, and universities, it is of utmost importance to divide the market analysis according to the type of entity, as the target audience for the obtained results varies. In this case, a classification is made based on whether it is a use case provider, a company participating in a use case, either SME or large, an RTO, or a university.

Once each entity has identified its specific exploitable results, it must determine the market share it will cover. This step is crucial, as it will determine its turnover, the market segment it will address, and whether it will target a regional, national, or international market.

Bearing these factors in mind, a solid market analysis can then be carried out. This analysis should be done considering five perspectives:

1. **Key market drivers**. Key market drivers are the main factors that intervene in the decision and possibility of bringing a product to the market. Therefore, it is necessary to identify the opportunities the market will provide for a product to be successful, as well as the possible barriers that must be overcome. Among these, one of them could be the legislation of each country, which may involve compliance with more or less strict requirements.
2. **Market trends**. Market trends are perceived as those changes and evolution in the buying and selling of products in a market. These trends are applicable to all assets and mainly include new products and movements in prices and volumes of buying and selling.
3. **Users' profiles**. It is essential to identify who our target user will be. Once identified, one must understand their needs and preferences and identify what challenges need to be overcome to meet those needs.
4. **Competitors**. It is advisable to analyse mainly direct competitors, i.e., companies offering the same or similar products and/or services to the same market segment. The potential competitiveness they may represent should be analysed, as well as identifying their value proposition and what added value each consortium partner offers over them.
5. **Stakeholders**. Stakeholders are those individuals who have a vested interest in a product. They can be primary, those who engage in economic transactions with the company, or secondary, those who, although they do not engage in direct economic exchanges with the company, are affected by or can affect the company's actions. It is useful to identify both groups and understand their decision-making process.

Knowing the target market will enable each entity to determine its KER, and therefore, the main differentiating element of each partner with respect to its competitors. The information from these five perspectives was gathered through a template that was shared with all partners.

Chapter 3 Final Exploitation Activity Report

This section covers the activities performed around the exploitation during the last year of the project. These activities include identifying the KERs, strategies for general exploitation, and specific actions for the particular exploitation of each of the partners.

In order to follow-up on the progress of the consortium's exploitation, a short survey was shared with the partners to identify each exploitation activity. For further information on the final exploitation plan of the project and its business plan, please refer to D6.13 [5].

3.1 Exploitation Actions Performed during the Project

Based on the discussions undertaken throughout the project, the strategies and the VALU3S exploitation itself have been constantly updated. These discussions were generated as a result of VALU3S collaboration with the Horizon Results Booster [6], a support initiative backed by the European Commission (EC). At the overall project level, these discussions were mainly centred around the KERs, which resulted in two Lean Canvas [7]. Also, during the last year of the project, the VALU3S exploitation management team has complemented the work developed with the Horizon Results Booster with additional material. On the other hand, at an individual level, each partner has focused on those exploitation activities in line with their business model.

3.1.1 Identification of VALU3S Key Exploitable Results

As indicated in deliverable D6.13 [5], and thanks to the discussions held with the Horizon Results Booster in the 'Assisting Projects to Improve their Existing Exploitation Strategy', 'Business Plan Development', and 'Intellectual Property Rights (IPRs)' workshops, the VALU3S consortium identified two outcomes as the KERs of the project, namely the web-based repository and the V&V-centred systems engineering tool suite. Additionally, during this last year, the consortium has decided to add a third KER to its portfolio: Verification & Validation Modelling Language (VVML). Below is a short explanation of the three results and their respective Lean Canvas.

Web-based Repository

This first KER is a layered multidimensional web-based repository consisting of a searchable catalogue of V&V methods and tools applicable to specific domains and application scenarios. Table 3.1 shows the Lean Canvas of this result.

V&V-centred systems engineering tool suite

This output aims to offer a holistic tailor-made solution with access to a wide set of validated tools to provide a customised service to meet the client's needs in terms of V&V of automated systems. Table 3.2 shows the Lean Canvas of this result.

Verification & Validation Modelling Language

This outcome is a new graphical domain specific language (DSL), named VVML and defined as a UML profile, which focuses on the workflows of V&V methods, identifying valid sequences of activities; artefacts that are consumed, produced, and shared; and the level of automation of each activity. Table 3.3 shows the Lean Canvas of this result.

Table 3.1. Web-based repository Lean Canvas.

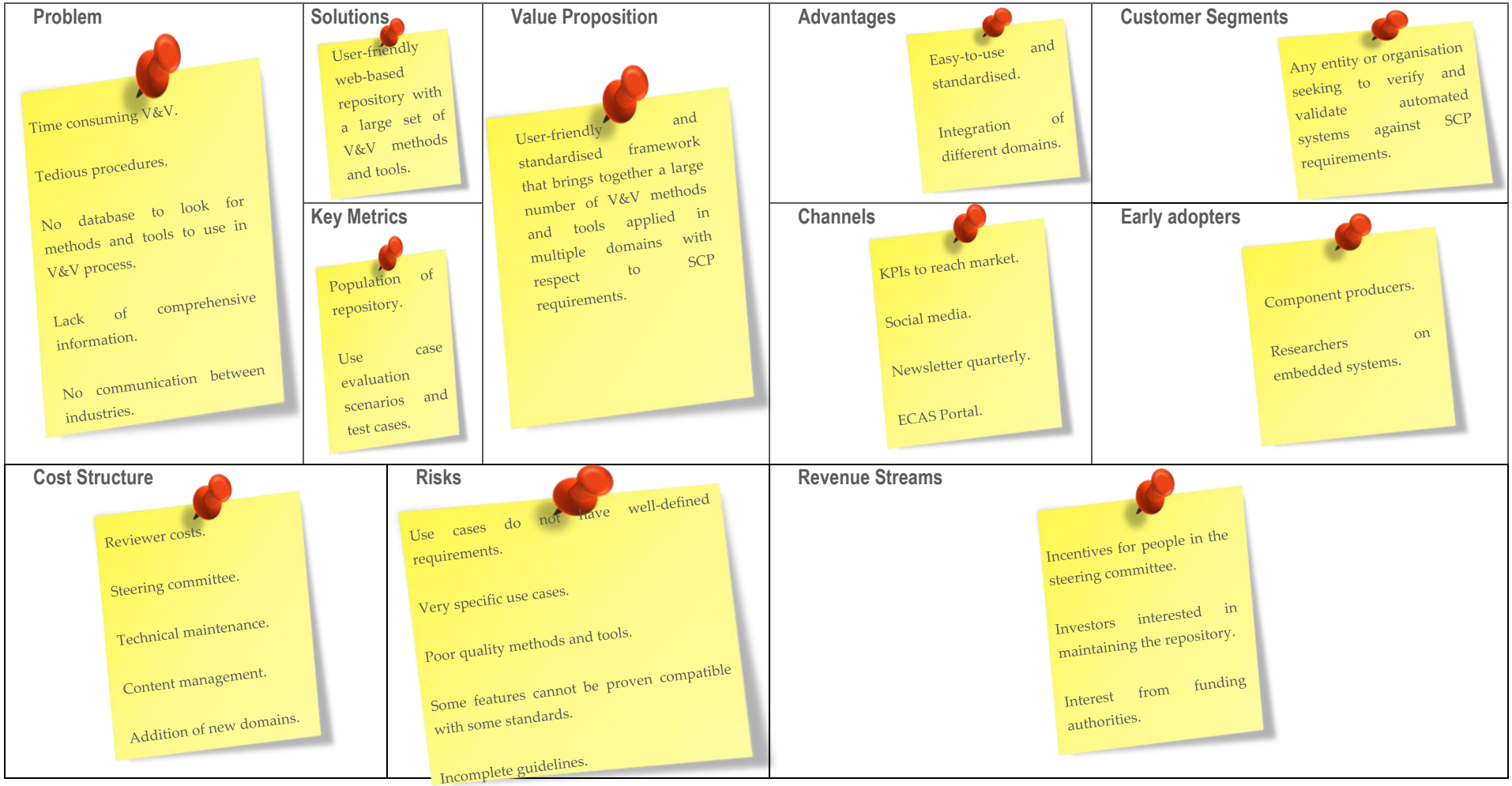


Table 3.2. V&V-centred systems engineering tool suite Lean Canvas.

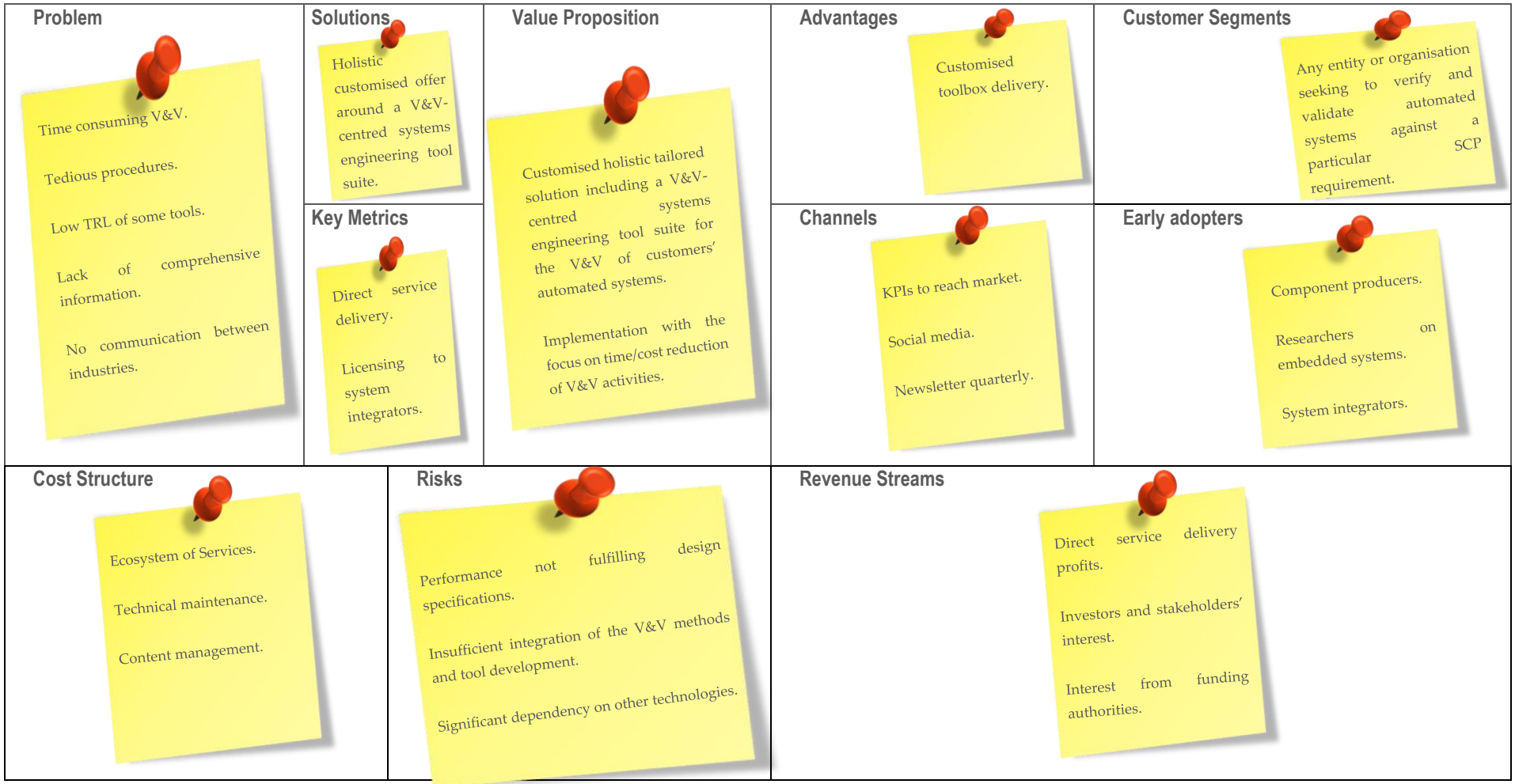
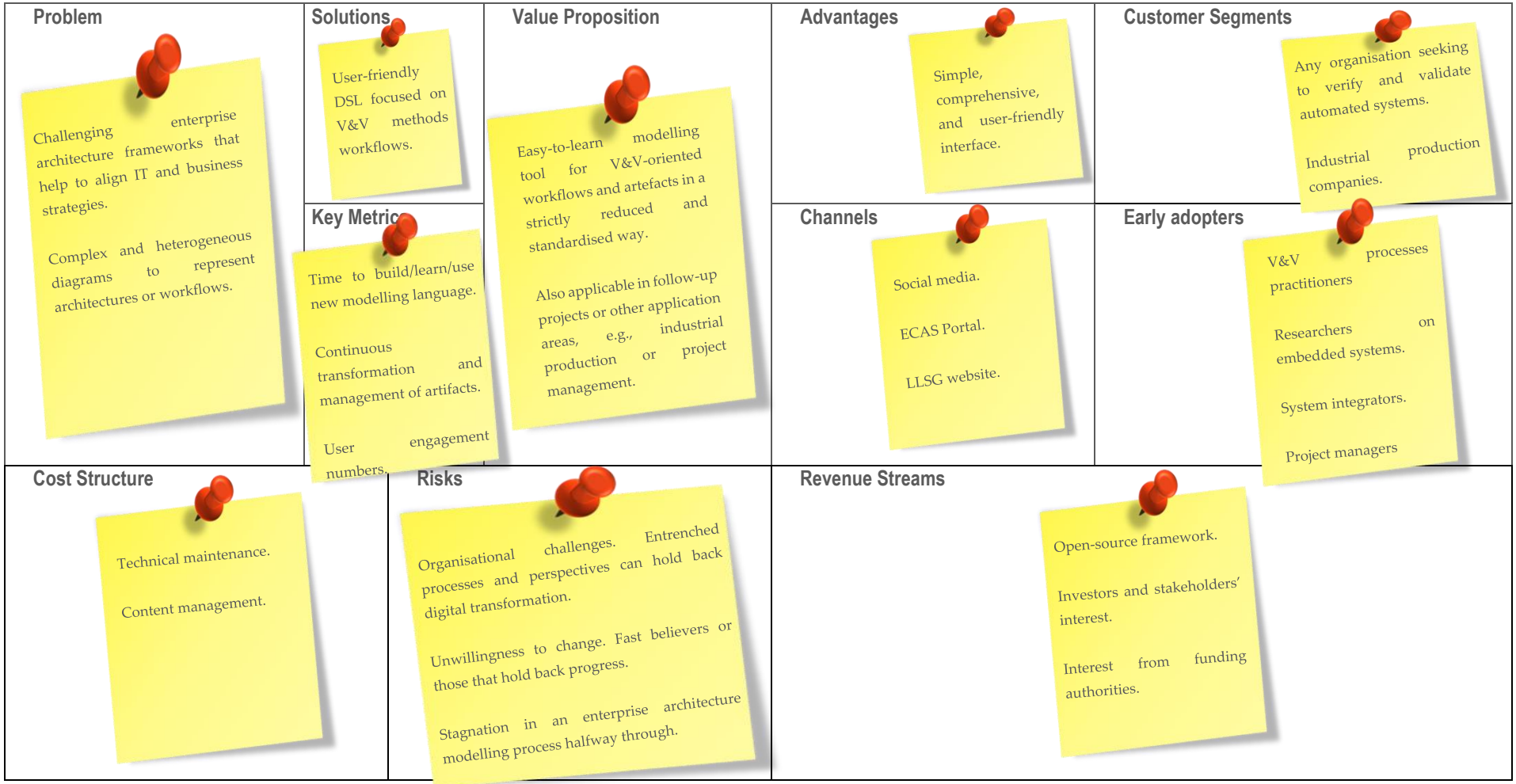


Table 3.3. VVML Lean Canvas.



3.1.2 Exploitation Services and Tools

Besides the workshops mentioned above with the Horizon Results Booster, over the last year, the VALU3S exploitation management team has worked on different aspects of the exploitation (e.g., material, a search of self-study courses and webinars) deemed useful for the members of the consortium:

- The European Patent Office (EPO) was contacted to request a workshop on IPR, with a special focus on patent registration. Since this workshop was not possible, free-of-charge available self-study courses were identified on the EPO website (e-courses.epo.org) for partners interested in patentability and patent registration.
- Regular emails were sent to partners informing them about free-of-charge webinars on the IP Helpdesk of the EC, with special emphasis on those focusing on the patent registration process, IP for SMEs, and IP commercialisation and licensing.
- The web-based repository[1] and the VVML[2] were uploaded as KERs on the Funding & Tenders portal to increase their visibility and dissemination and to engage a larger number of stakeholders.
- A leaflet that partners could hand out at their workshops or conferences was also created to raise awareness and increase the number of views of the VALU3S web-based repository (Figure 3.1).

Figure 3.1. VALU3S web-based repository brochure.

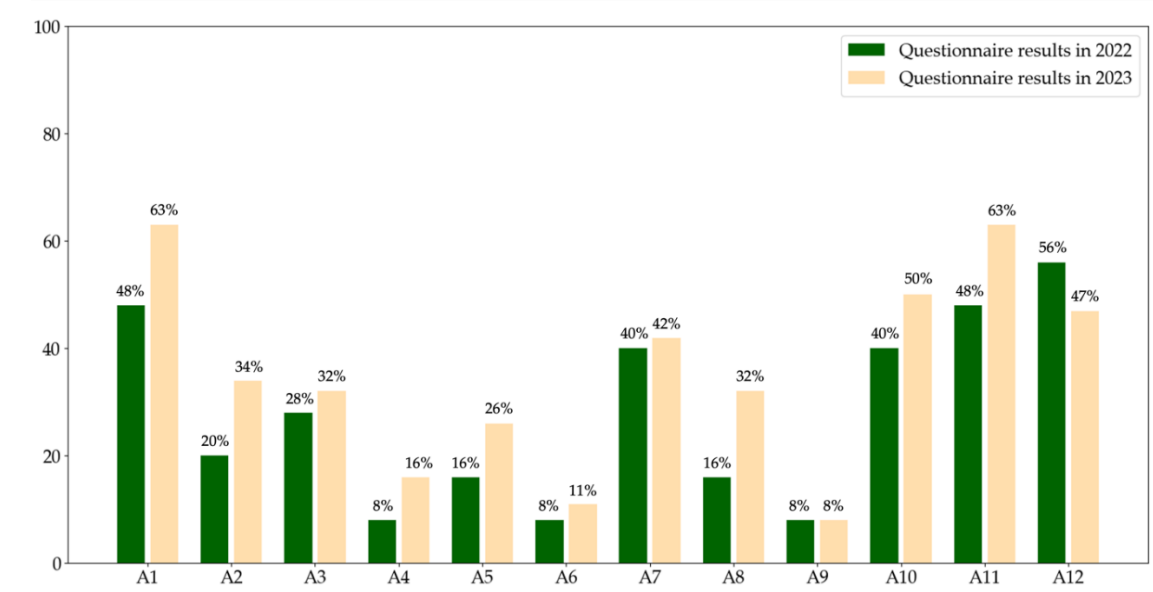
[1] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform/51982

[2] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform/57775

3.1.3 Consortium Exploitation Progress Monitoring

During the last year of the project, most partners have worked extensively on exploitation-related activities. This is clearly reflected in the 85% (35/41) of partners who have participated in the latest shared questionnaire on the exploitation activities they have carried out during the third year of the project compared to the 68% (28/41) who participated in last year's questionnaire.

Figure 3.2 shows the results of the survey shared and how most of the participation rates have increased from the results of D6.16 [1].



Legend

A1. Focus on the main results and their commercial viability

A2. Consider new business and operating models for bringing the project results to customers.

A3. Put a strong focus on how stakeholders can profit from the exploitation of the results.

A4. Develop a timeline for exploitation. Identify the prospective time frame after the end of the project to bring results to the market.

A5. Identify concrete customers' needs and describe ways to quantitatively measure the success.

A6. Involve marketing, product-management, and sales department early in the process.

A7. Start exploitation of intermediate results already during the project.

A8. Consider non-technical developments (legal aspects, privacy aspects, etc.) and their influence on exploitation.

A9. Protect intellectual property.

A10. Offer seminars, lectures, courses, and the-like with topics related to the project

A11. Acquire new projects and research related to the present project for further funding.

A12. Ensure that students gain valuable knowledge by their work in the project, which they will take to industry.

Figure 3.2. Percentage share of VALU3S partners in exploitation activities during the third year.

However, despite the increase in the share of exploitation activities, the five activities put most effort into are again the same as last year:

1. **A1. Focus on the main results and their commercial viability**. Thanks to the market analysis, more than half of the partners who have carried out activities related to the project have focused on what its main results and commercial viability will be. According to the Horizon 2020 glossary [8], a result is defined as "any tangible or intangible output of the action (such as data, knowledge, and information, whatever their form or nature, whether or not they can be

protected), which are generated in the action, as well as any attached rights, including intellectual property rights". This analysis, in turn, has led to the identification of the KERs. Following the definition of "result", a KER is an identified main interesting result that has been selected and prioritised due to its high potential to be "exploited" (meaning to make use and derive benefits) downstream the value chain of a product, process or solution, or act as an important input to policy, further research, or education.

In order to select these KERs, three main aspects should be considered: 1) the degree of innovation, 2) the exploitability of the results, and 3) the impact it will have on the market. Based on these criteria, most of the VALU3S partners have identified their own KER. These results can be found in Appendix A.

This exploitation activity can also be extrapolated to VALU3S KERs in general. Specifically, the efforts made by the consortium to promote the web-based repository have paid off, more than tripling the target value expected for *Exp-KPI-7. Web repository visits* for the end of the project at the end of April 2023. In this regard, almost half of the visits came from the United States (Figure 3.3).

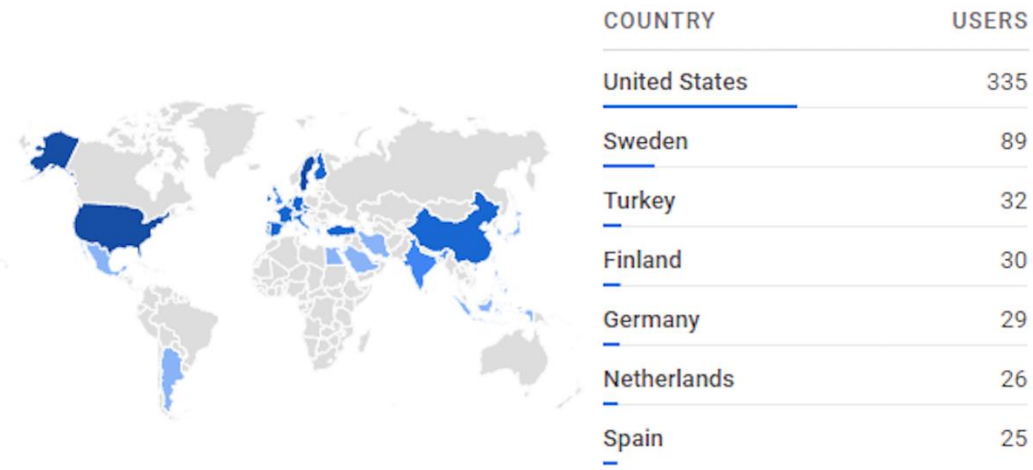


Figure 3.3. Web-based repository visits by country.

2. **A7. Start exploitation of intermediate results already during the project**. Due to the maturity of certain individual results, several partners have already started to exploit some of these results. This has been clearly reflected in *Exp-KPI-3. (Potential) agreements with early customers or stakeholders*. While the aimed target value of 25 or more potential agreements with early customers or stakeholders has not yet been reached, the value of the KPI has increased from only 3 in D6.16 [1] to 15. However, other KPIs, such as *Exp-KPI-2. Beta testing agreements* are still far from the established values, concluding at the 15 agreements reached last year.
3. **A10. Offer seminars, lectures, courses, and the-like with topics related to the project**. Several partners have also offered seminars, conferences, and courses on a project-related topic. This is another form of dissemination that enhances the visibility of the project for future exploitation.
4. **A11. Acquire new projects and research related to the present project for further funding**. A considerable number of partners have been working on the acquisition and awarding of new

projects related to VALU3S. In this way, they expect to obtain more funding and thus to be able to aim for higher quality results.

5. **A12. Ensure that students gain valuable knowledge by their work in the project, which they will take to industry**. Just like the A10 activity ("Offer seminars, lectures, courses, and the-like with topics related to the project"), this activity is in turn related to the teaching field and to the purpose of providing students with valuable knowledge through their work on the project, a task that has been addressed by the universities involved in the project. Clearly, A10 and A12 have been two of the most worked exploitation activities by the RTOs and the universities. Indeed, *Exp-KPI-4. Teaching and academic education activities*, directly related to both tasks, has more than doubled compared to its target value.

Likewise, the three activities least addressed by the partners are also the same as in D6.16 [1]:

1. **A4. Develop a timeline for exploitation. Identify the prospective time frame after the end of the project to bring results to the market**. Although exploitation of some results has taken place, many partners at the beginning of the project did not know what the final scope would be. Moreover, as some demonstrators are at low Technology Readiness Levels (TRLs), it is logical to think that this task has been one of the least worked on during the last year as it was not known exactly when a product could be brought to market.
2. **A6**. **Involve marketing, product-management, and sales department early in the process**. Although not many partners have contacted their sales department for the dissemination and exploitation of their outcomes in the project, VALU3S has enabled the recruitment of four traders, which in turn has led to successfully reaching and exceeding *Exp-KPI-5. Traders recruited*.
3. **A9**. **Protect intellectual property**. This task has been the least worked on during the project. Despite the efforts made by the VALU3S exploitation management team to promote IPR protection, only one partner has registered a patent ("Automatic Trajectory Generation for Part-Based Operations in Robotic Systems"). In general, partners have preferred to publish scientific papers. For more information in this regard, see the deliverable D6.19 [9].

3.2 What is Next? Future Exploitation Actions

The exploitation of VALU3S has been a continuous process from the beginning of the project until its end. Many partners have been involved and committed to its accomplishment. These efforts have resulted in the partial or total achievement of many KPIs set at the beginning of VALU3S. However, in those cases where the target values have not been reached, it is worth pointing out that much of the exploitation of the results will continue after the end of the project. Therefore, the remaining KPIs are believed to be achieved months after the project completion.

Furthermore, the consortium hopes that the overall outcomes obtained within VALU3S are not forgotten but may lead to new partnerships and business models for future exploitation. Bearing this in mind, a designated group within the consortium has been meeting once every two weeks since the

beginning of the project to discuss and propose new ideas to boost the sustainability of VALU3S results after the end of the project. For further information on these new avenues, see Chapter 5.

Chapter 4 Short/Long-Term Market Analysis

This section presents the updated short- and long-term market analysis for VALU3S, including the impact of the still remaining coronavirus pandemic [2], the Ukraine crisis [3], and the recent natural disaster in Turkey and Syria [4]. This analysis has been conducted regarding the domain in which the different use cases are included, as well as the target geographic regions to be addressed.

The long-term analysis (after completion of the project onwards) includes:

- European Single Market[3].
- European Market of Non-EU Member Countries and Neighbouring Partner Countries[4].
- Russia and Asia.
- Latin America.

4.1 Automotive Domain

4.1.1 Short-term Market Analysis

Automotive Market Overview

In 2020, global automotive sales were hit hard by the pandemic [2], with global automotive production down by an estimated 13% [10], and the number of cars sold by 15.3% [11]. However, this market's recovery, particularly light cars, started to pick up in 2021 [12], although shortages of semiconductors hindered the expected growth [13].

Interestingly, in this context of market contraction due to supply chain issues, electric and hybrid vehicles increased their market share the most. The biggest case in point was Tesla, the fastest-growing car brand among all brands throughout the pandemic, with a brand value growth of 271% [14].

Now in 2023, forecast sales for the next 12-month period look set to return to pre-pandemic levels, with a growth of around 9%. Once again, electric and hybrid vehicles are expected to lead the way, with a growth of 29% year-on-year in 2023, to reach an estimated 12.1 million units worldwide [12]. This growth will be boosted by improved battery performance and the expansion of charging infrastructure [15].

Notwithstanding, the automotive industry continues to face significant global disruptions. Not only the supply chain interruptions caused by the pandemic, but other global socio-economic elements, such as tensions in Asia-Pacific [16], the war in Ukraine [3] and the consequent rise in fuel prices [17], or the recent earthquakes in Turkey and Syria [4] are creating a climate of uncertainty and hesitation. As a result, automakers are expected to shift from "just-in-time" to "inventory banking" strategies to increase

[3] Please note that although Switzerland is outside the EU, it participates for the most part in the European Single Market.

[4] The analysis of the European Market of Non-EU Member Countries and Neighbouring Partner Countries comprises Turkey, Israel, Serbia, and Croatia.

supplies, despite additional inventory costs. Manufacturers are likely to consider vertically integrated business models, particularly in the battery value chain, with localised battery manufacturing rather than importing cells from one or two large suppliers [15].

Automotive V&V and Testing Market Overview

The global automotive test equipment market is forecast to reach almost USD 601 million in 2023, with a year-on-year growth of more than 6%. This increase will be supported by the above-mentioned rise in vehicle production, installation of test equipment at original equipment manufacturer (OEM) plants and growing awareness about vehicle testing drives. In addition, stringent government regulations and curb carbon and other non-green emissions are also expected to foster demand on automotive test equipment [18].

Within vehicle production, autonomous cars will play an important role in the demand for testing and V&V processes [19]. It is obvious that self-driving cars require thorough testing to ensure safety. Simulation software will be in high demand in this regard, as they allow for cheaper testing prior to track or public road testing. Thus, the implementation of V&V processes to avoid vehicle failures as well as cyber-attacks will be an essential requirement [20].

4.1.2 Long-term Market Analysis

Amid the coronavirus outbreak [2], Oxford Economics forecasted a steady increase in car production but warned that this growth would be subject to how quickly manufacturing sectors could re-mobilise complex multinational supply chains [10]. Based on the latest reports on the global automotive market [21], the predictions are highly positive, expecting the market to reach a value of USD 3272.6 billion by 2028 at a compound annual growth rate (CAGR) of 3.01% over this period and almost doubling what it was worth in 2019 [22]. Meanwhile, the testing, inspection, and certification automotive market is projected to grow from USD 19.3 billion in 2021 to USD 28.5 billion in 2028 at a CAGR of 5.75% during the same period [23]. Nevertheless, the main challenge for the coming years will be to rebuild production, although other triggers may comprise this goal.

One of these triggers is the Ukraine crisis [3]. Already last year, global automotive production is estimated to have been cut by 400.000 units due to the war, reducing car sales [24]. With no clear progress in negotiations, the automotive value chain has been highly disrupted over the last year, leading OEMs and suppliers to postpone or interrupt trade with Russia. OEMs such as Toyota, Ford, Volvo, Jaguar-Land Rover, General Motors and BMW have ceased their export operations to Russia, and many have suspended their Russian joint ventures in response to the invasion [25].

On the other hand, another trigger may be the earthquakes in Turkey and Syria [4]. In particular, many OEMs have large facilities in Turkey. Although there have already been reports from Asian automotive companies reporting no damage to their facilities [26], the possible consequences of this natural disaster for other companies worldwide are still unknown.

While most reports and market analyses consider the uncertainty generated by COVID-19 or the war in Ukraine, these recent socio-economic events and future one may disrupt the prediction made for global automotive market growth in the coming years.

Once the project is completed, the updated expectations for this domain for the four markets covered by VALU3S are analysed below. The individual market analyses for the use case providers, SME/large organisations contributors, RTOs, and universities in the automotive domain are presented in Appendix A.1.1, Appendix A.2.1, Appendix A.3.1, and Appendix A.4.1, respectively.

European Single Market

The automotive industry is one of the mainstays of the European economy. According to [27] published in 2021, the automotive sector alone directly or indirectly employs over 13.8 million Europeans, accounting for 6.1% of the total employment in the European Union (EU). The sector also represents the largest private investor in research and development, making the EU one of the world's largest vehicle producers, including Volkswagen, Mercedes-Benz, Volvo Cars, and Fiat, among others.

Although this sector in Europe was one of the hardest hit by the pandemic, and the current crisis in Ukraine may cause some difficulties, the latest reports predict that the lightweight car market alone will register a CAGR of about 9% by 2027 [28], and that the automotive vehicle market is expected to reach almost 22 million units by the end of the decade [29].

Milestones on the road to this future state primarily include the development of a customer-centric mobility industry, the achievement of a leading position in sustainable mobility solutions, and the creation of superior and sustainable economic value for all stakeholders [30]. These milestones will be partly driven by market trends, where electric cars are taking centre stage.

Indeed, all European car manufacturers expect to increase the supply of electric vehicles extensively in the coming years, with Volkswagen Group leading the way. This change in strategy is also reflected in the industry's long-term goals, with almost all OEMs committing to ambitious electrification targets for 2030. The new mandatory emissions limits represent a turning point in the speed of growth of electric vehicles in Europe, with a noticeable jump in the number of vehicles available. In this regard, European brands appear to be well positioned relative to non-European manufacturers and account for most of the models available in Europe [31].

European Market of Non-EU Member Countries and Neighbouring Partner Countries

The automotive industry is one of the largest sectors in Turkey, which is the centre of several European and Asian manufacturers that invested in production facilities to meet domestic demand while exporting to Europe [32]. Reports from the beginning of 2023 predicted a strong rebound in vehicle demand over the next years in the Turkish market following the economic crisis and the bottlenecks in the post-pandemic supply chain. In fact, the market was expected to grow at a significant CAGR between this year and the end of the decade. This increase was underpinned by the growing adoption of electric vehicles and increasing demand for advanced safety, connectivity, convenience, and driver assistance features that the modern automotive industry is shaping in Turkey [33]. However, recent earthquakes in the territory could disrupt this growth, at least in the short term. So far, several car brands have reported that their facilities have not suffered any collapse [26], and many others, such as Toyota, have made material and financial donations [34].

As far as Israel is concerned, the impact of the pandemic was even greater than in Turkey, significantly affecting sales, which fell by 15% in 2020 compared to 2019 [28]. However, although the 2022 statistics

from Statista were not very encouraging for the market in the country, predicting a CAGR of -1.07% in the passenger car market until 2026 [35], these figures have improved slightly during the last year, with new surveys predicting a CAGR of 2.08%, resulting in a projected market volume of USD 7.79 billion by 2027 [36]. The Israeli smart mobility market is one of the market segments expected to grow the most over the next years. This is due to leading Israeli companies and start-ups operating mainly in shared mobility, fleet management, connected vehicles, autonomous cars, and electric mobility, which are expected to support the growth of the Israeli smart mobility market.

For the Balkan countries surveyed, namely Serbia and Croatia, the car market is expected to grow in the coming years. In the case of Serbia, the country already reported an increase of 16.4% in 2021 compared to 2020 [37] and given that this industry is certainly the most important industrial today in the country, an increase in foreign investments is also expected [38]. Croatia, meanwhile, reported an even greater increase in 2021, with a 25.5% increase in sales [39], [40]. Also, according to Statista data from the end of 2021, the country's automotive market is projected to reach USD 79.33 million by 2025 [41].

Russia and Asia

New car sales in the Russian market already fell by 2.4% in 2019, with production declining by 2.5%. This was due to the slowing economic growth, lower oil prices, and the devaluation of the Russian rouble, all of which affected consumer spending [42].

Three years ago, at the height of the pandemic lockdown, the closure of several Chines manufacturing companies supplying Russian companies caused their production to cease, resulting in the Russian car market dropping by 19.1% between January and March 2020 [43].

Moreover, the war in Ukraine [3] further devalued the rouble due to Western economic sanctions. In this respect, the automotive sector suffered one of the biggest fallouts, and major car brands closed their plants in Moscow and St. Petersburg [44]. As a result, the industry experienced a collapse in light vehicle production of almost 97% three months after the start of the war and a drop in car sales of more than 80% when the crisis reached its peak in May and June last year [45].

Car sales have now almost doubled since May, thanks to a fragile turnaround that has taken hold thanks to government spending and monetary stimulus, helped by a surge in vehicle imports from China [45]. Based on [46], the market is expected to grow at a significant CAGR between 2023 and 2030. Other reports, by contrast, are more conservative, and forecast that, while vehicle production will rise at an average rate of around 0.3% year-on-year by 2026, vehicle registrations will decline by 2.5% year-on-year over the timeframe analysed [47].

In Asia, in turn, key markets such as China, South Korea, Japan and Taiwan recovered strongly from the small decline they experienced during the period with the highest contagion rate. This was due to the rapid response of consumers to strong domestic market stimulus, including low interest rates and tax incentives, and new models [47].

Asia-Pacific is now estimated to be the largest automotive market by 2025, growing at over 7% during the forecast period. Developments in the field of engine technology are increasing significantly, along with the rising emission standards worldwide. These factors contribute substantially to the growth of

the global automotive engine market. The increasing adoption of electric vehicles in Asia-Pacific is also expected to drive the production of automotive engines. Specifically, attractive government incentives to popularise electromobility and increasing investments by automakers are anticipated to drive the market [48].

The automotive aftermarket in Asia-Pacific is also likely to undergo significant changes in the coming years. Automakers such as Tesla, Hyundai, Google, Nissan, Mercedes, Ford, and Volkswagen are leading the change by leveraging cutting-edge technologies such as AI, machine learning, and robotic engineering in vehicles. Digitalisation, together with the inclusion of these technologies, will definitely boost the development of this industry [49].

The initiative for electric vehicles and emissions reduction also extends to Southeast Asia, where according to a report by the International Renewable Energy Agency, by 2025, around 20% of vehicles on its roads will be electric, including 59 million two- and three-wheelers and 8.9 million four-wheelers [50]. In addition, countries such as Thailand aim to become an electric vehicle hub by 2025, with an ambitious vision of electric vehicle production reaching 30% of total production by 2030 as the ultimate goal [51].

Latin America

The Latin America passenger car market is steadily recovering after most countries were strongly affected by inflation, the economic crisis, and the coronavirus. Indeed, this market offers great potential for the automotive industry, as car ownership in the region is currently low and disposable income is growing very rapidly [52]. Some experts forecast Brazil, Argentina, Chile, Ecuador, and Peru to be the countries that will drive the car market the most, which is expected to grow at nearly 5% CAGR by 2027 [53]. In fact, in Brazil, with an improving economy and increasing credit availability to support the country's vehicle market, growing investment, and strong export demand, the country has witnessed positive growth in vehicle demand and sales.

Other studies, on the contrary, point to countries such as Uruguay, Mexico, or Colombia where the car market is most likely to grow [54], [55]. In the case of Colombia, for instance, it currently ranks as the third-largest automobile assembler in South America (after Brazil and Argentina) and as the second-largest motorcycle producer in the region. The country has plants for the assembly of light vehicles and trucks, buses and motorbikes, and manufacturing of parts used in assembly for OEMs. However, the industry is currently unable to meet local demand and relies heavily on imports of vehicles and auto parts.

On the other hand, The Latin American electric vehicle market is also expected to grow at a CAGR of over 30% in volume over the next five years. So far, the region has contributed the least to the global market, with a share of less than 1%. However, the commercial electric vehicle segment is expected to grow at over 25% by 2027. Factors such as achieving energy efficiency by reducing emissions and addressing future energy requirements have led OEMs to start producing electric vehicles in the region [56].

4.2 Agriculture Domain

4.2.1 Short-term Market Analysis

Agriculture Market Overview

The spread of the coronavirus mainly affected the agricultural market in terms of food supply and demand [57]. While the former was primarily due to the border closures, which hindered cross-border trade, and preventive measures enacted by some governments that kept agricultural workers from cultivating their land, the latter varied considerably depending on food prices, consumer income levels, socio-demographics, consumption and purchasing preferences, and lockdown restrictions [58]. However, according to [59], from 2022 onwards, prices were expected to recover gradually but remain below baseline levels for some time.

Notwithstanding, last year's and still ongoing humanitarian crisis in Ukraine [3] has jeopardised the recovery of the agricultural market. This is because Russia and Ukraine are among the most important producers of agricultural products globally. Both countries are net exporters of agricultural products and play a leading role in global food and fertiliser markets, where exportable suppliers are often concentrated in a limited number of countries. As an example, over the last 5 years, the two countries together accounted for 13% of world wheat production and 30% of world wheat exports [60]. Consequently, this war could expose many countries' imports to greater vulnerability to crisis and volatility [61].

Last year in Ukraine, the war led to the closure of ports, the suspension of oilseed crushing operations, and the introduction of export licensing requirements for some crops, all of which took their toll on the country’s cereal and vegetable oil exports. The most recent data from the UN Food and Agriculture Organisation estimate that the war has cost the Ukrainian agriculture sector between USD 4 billion and USD 6 billion. The estimated cost of replacing and repairing damaged agricultural machinery alone is so far estimated at USD 926.1 million, or 2.281 units of agricultural machinery. Further, the cost of damaged or destroyed grain storage facilities is estimated at USD 272 million, and the value of lost livestock is around USD 136 million [62].

The agriculture market will also suffer in the coming months in Turkey. The earthquakes in the Turkish region near Gaziantep (Figure 4.1), a city with a large agriculture-based industry [63], will be a severe blow to the country, where agriculture accounts for 6.6% of gross domestic product (GDP) and, according to the World Bank, about one in five Turkish citizens is employed in this industry.

The ten affected provinces account for 15% of total agricultural GDP and form a powerful agricultural hub, whose exports last year reached USD 21.5 billion, or 8.5% of all Turkish exports. In this regard, Gaziantep accounted for half of the total volume [64].

Figure 4.1. Earthquake damage to Turkish crops [64].

Agriculture V&V and Testing Market Overview

Although the most recent reports on the global agricultural testing market do not consider some of the socio-economic events mentioned above, it is safe to say that the market is expected to experience a sharp rise due to the increased demand for agricultural products, which translates into an increase in production and thus the need for regular soil testing. Similarly, the shift in consumer preferences towards a higher level of food safety and quality in terms of chemical residues creates the need to maintain soil fertility, the quality of water available for irrigation facilities, and the development of crops and other agricultural products [65], [66].

Similarly, in the short/medium term, numerous technological developments, such as the increasing integration of the Internet of Things (IoT) and AI, are expected to provide real-time information on remotely located and under-treated fields, thereby driving the agricultural testing and V&V market [67].

4.2.2 Long-term Market Analysis

Despite the impact of the coronavirus [2], the food and agriculture sector demonstrated greater resilience to the pandemic than other domains. After the initial economic contraction at the onset of the pandemic, projections assumed a generalised economic recovery from 2021 onwards. However, the level of global GDP in 2030 is projected to remain below pre-pandemic projections, as the GDP lost during the pandemic is not expected to be fully recovered.

The report launched by the Food and Agriculture Organization of the United Nations (FAO) additionally highlights the important role that public and private investments will play in increasing productivity. Over the next decade, global agricultural production is expected to increase by 1.4% annually, mainly in emerging economies and low-income countries. This will be triggered by wider access to inputs and investments in technology, infrastructure, and agricultural training to improve productivity, which are key drivers of agricultural development [68].

Likewise, investments to improve farm performance and management will drive growth in global agricultural production. Assuming that the transition to more intensive production systems continues

over the next decade, 87% of the projected growth in global crop production is expected to come from yield improvement, 7% from increased cropping intensity and only 6% from cropland expansion [68].

Once the project is completed, the expectations for this domain for the four markets covered by VALU3S are analysed below. The individual market analyses for the use case providers, SME/large organisation contributors, RTOs, and universities in the agriculture domain are presented in Appendix A.1.2, Appendix A.2.2, Appendix A.3.2, and Appendix A.4.2, respectively.

European Single Market

Prior to the coronavirus pandemic [2], the European Union (EU) economy was expected to grow by 15% between 2019 and 2030. Due to the pandemic, this was revised downwards to 10% in the baseline, including the coronavirus shock (an annual difference of 4.5 percentage points in 2022-2030) [69]. This also affected the European agriculture sector. However, the report released by the EC at the end of 2020 anticipated that this situation would be reversed in the coming years and pre-pandemic trends would be recovered. Nevertheless, the Russian invasion of Ukraine last year has once again created a climate of uncertainty to agricultural markets and global food security. This is because Ukraine has played an important role in the European cereal market. In addition, many raw materials for the production of edible oils, for example, have been imported into Europe from Ukraine.

The latest EU report [70], presented in January 2023, predicts that, compared to a peak in 2022, due to the temporary derogation allowing the use of fallow land to ensure food security after the war in Ukraine and due to high prices for the oilseed, the areas used for rapeseed and sunflower production in the EU will decrease in the future. However, this reduction will be more than counterbalanced by an increase in the soya bean and pulse-growing areas.

The EU is due to remain a net importer of oilseeds and protein crops until 2032, although growth is expected to slow, and net oilseed imports are expected to fall from an average of 20.0 million tonnes in 2020-2022 to 17.5 million tonnes in 2032. Also, the sugar area will slowly decrease as some growers switch to other crops given the challenges posed by plant protein products available for sugar beet. Therefore, EU sugar production could be reduced to 15.5 million tonnes. Domestic sugar consumption will decline faster than production. This could allow EU sugar exports to grow and, by 2032, they are expected to reach the level of imports.

European Market of Non-EU Member Countries and Neighbouring Partner Countries

Historically, the agricultural sector has been Turkey's largest employer and a major contributor to the national economy [71]. However, due to the coronavirus outbreak, according to the Turkish Statistical Institute [72], Turkey's agricultural GDP declined by around 50% between the third and fourth quarters of 2021. Notwithstanding, according to Trading Economics [73], the market was expected to recover and the GDP to grow by more than 60% during 2023.

Nevertheless, the recent earthquakes in Turkey have disrupted this recovery. Although official data on the country's economic growth for last year is not yet available, it is expected to be between 6 and 7%. The forecast for 2023 was 5%, but considering the consequences of the earthquakes, experts believe that an economic growth rate of 3% is more realistic. This could mean that the state budget deficit, projected at 3.5% of GDP in 2023, could increase to 5% of GDP [64].

Also, dwindling agricultural supplies could trigger food inflation, which was 71% in January. Turkey is the largest producer of certain nuts (e.g., hazelnuts), whose orchards were concentrated in the earthquake zone. As a result, prices for this product could rise, and fruit and vegetable exports from the affected provinces will inevitably slow down [64].

It is still early to determine the extent of this natural disaster in the medium/long term on the farmer's market. However, forecasts before the earthquakes were encouraging. Agricultural input manufacturers, retailers, farmers, and food processors and manufacturers were rapidly emerging across the value chain amid strong prospects for market growth in the coming years. The Turkish government is also encouraging investment in agribusiness to promote effective strategies for improving food security and as a vital source of economic development [74].

Indeed, thanks to these supportive policies, the performance of the agricultural sector has been steadily improving in recent years, with the country ranking first in the world in agricultural production, with large quantities of rice, wheat, cotton, meat, poultry, eggs, and fishery products [75].

However, this growth over the next years will also be conditioned by the war in Ukraine [3]. Russia is one of Turkey's biggest partners in terms of exports and imports, with Russia buying citrus fruits, grapes, and tomatoes from Turkey, as well as agricultural machinery to process these products, and Turkey importing many other agricultural products from Russia [76].

One important product is wheat, with Turkey importing 64.6% of its wheat from Russia and 13.4% from Ukraine, according to Bianet. In 2021, the country's total wheat imports were valued at USD 1.8 billion. Another product is the sunflower, which Turkey imports 65.5% from Russia and 4.2% from Ukraine for processing domestically. All this could cause Turkey's agricultural GDP to grow significantly slower than predicted a couple of years ago [76].

As regards Israel, its agriculture is exceptionally unique, as land and water resources are mostly state-owned and cooperative communities control agricultural production. Its production peaked in 2018, with the production of oilseeds, pulses, fruits and vegetables, cereals and grains, cash crops, and roots and tubers [77].

However, like Turkey, Russia's invasion of Ukraine placed Israel in a troublesome situation. Israeli exports of goods and services to Russia amount to USD 1 billion a year, 26% of which are agricultural products. Likewise, imports from Russia amount to USD 2.5 billion, with half of the wheat imported into the country coming from Russia, while another 30% comes from Ukraine [63]. Nonetheless, according to the latest reports from the end of 2022 [78], the agriculture market in Israel is estimated to grow at a CAGR of 4.98% between 2022 and 2027. This growth will be driven by the growth of the organised retail sector, the high level of investment in research and development in the country, the expansion of water resources, and the booming food processing industry.

In turn, agriculture and food production have always been crucial sectors in Croatia and Serbia. The latter, specifically, is the largest agricultural market in the Western Balkans, and the sector accounts for over 10% of the country's GDP and around 20% of all exports [79]. Both countries have large stocks of wheat, maize, flour, and cooking oil, so the agricultural market will not be affected. In fact, they will

supply these cereals to neighbouring countries such as Bosnia-Herzegovina and Montenegro [80]–[82]. In addition, both countries have launched supportive policies and incentives to back agricultural production in the best possible way in underdeveloped and less favourable areas by improving the competitiveness of agricultural farms [83], [84].

Russia and Asia

The agriculture market was and remains one of the most stable in Russia. The country's most important crops are sunflower oil, cereals, and corn [69]. Moreover, it had recently become a major player in international wheat markets, surpassing the EU in exports.

However, the sanctions packages imposed by the West on Russia last year appeared to have made agricultural buyers theoretically reluctant to commit to Russian supplies. In addition, banks are less willing to finance Russian commodity trade, which seemed likely to weigh further on Russian supply on the world market.

However, despite a short-term demand shock for Russian grain, Russian agricultural GDP more than doubled from the second to the third quarter of 2022 [85]. In fact, Russian shipments since the war are holding up better than Ukrainian shipments, with figures almost identical to previous years (Figure 4.2).

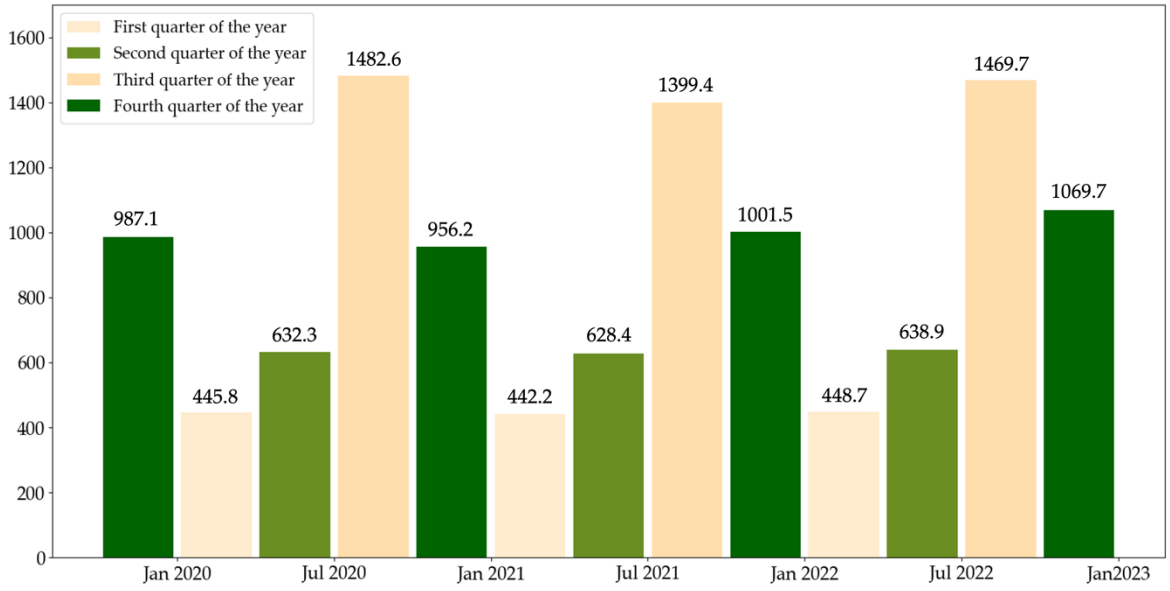


Figure 4.2. Revenue statistics for agriculture in Russia for the last two years (RUB billion) [85].

Sanctions seem not to have affected the Russian agricultural market, at least not in the past year. However, their impact on many of this year's crops remains unknown. Should Russian commodities continue to be sanctioned, and should these sanctions have a real impact, we could start to see farmers react by reducing the area under cultivation. This could be reflected in future harvests, where there is a possibility that the current uncertainty will lead to a reduction in plantings [86].

On the other hand, although agricultural production growth has slowed in recent years and will continue to do so in the coming years, mainly due to maturing domestic markets, policies, and global trade competition, Asia is the world's largest producer of agricultural commodities.

The continent is a major producer of cereals, especially rice, with a production share of close to 90% globally [87]. Its contribution to rice, wheat, and other coarse grains is expected to remain stable over the next decade. In fact, Indian rice and wheat production will be one of the most relevant, and this country's agricultural market is expected to grow at a CAGR of 6.8% by 2025 [88]. Likewise, the Southeast Asian seed market is expected to register a CAGR of 6.4% by 2025 [89]. Conversely, declining maize stocks in China could create opportunities to diversify production into other commodities.

As in other regions, the area under cultivation will shrink, so productivity improvements will drive production increases. By 2025, the Asia Pacific smart agriculture market is forecast to rise at an influential rate. Currently, China holds the leading share in the Asia Pacific smart agriculture market. However, in the forthcoming years, Japan is expected to showcase more attractive opportunities for the market [74].

Latin America

Before the pandemic, the agricultural sector showed a clear upward trend in the coming years on the Latin American continent. However, as in the rest of the world, this increase came to a partial halt. Specifically, among the main Latin American countries, the shortage of agricultural labour during the harvest and the crisis in the supply of inputs, which in turn hampered the countries' usual production, were the main factors that affected during the pandemic [90].

Nevertheless, the productive growth of the sector will continue, where the improvement will be mainly in productivity rather than in expanding arable land. Hence, demand will be determined by population growth, the income of each region, and its main markets [91].

Regarding oilseeds, soybean production has increased considerably in recent years, mainly in Argentina, Brazil, and Paraguay, where land expansion for cultivation has been remarkable. This production will continue growing in the next decade, with more land allocated to soybean cultivation. In terms of legumes, beans are one of the most important in the diets of many Latin American countries. In this regard, its production is expected to remain relatively stable, with a small growth rate of around 1% in the coming years. For tubers, production has grown relatively slowly in the region. While production has been declining in Brazil, in several Central American countries and in Peru, production has been increasing and is expected to continue to grow over the next decade. Fruit and vegetable production is also expected to increase across the continent over the next decade. This production will be even more remarkable if aspects such as storage technology, infrastructure, and production practices are improved [91].

Finally, the South American continent is the world's leading exporter of coffee par excellence. Brazil is the world's leading coffee producer and exporter, ahead of Colombia, Honduras, and Peru. The region's production potential is supported by growing consumption in emerging markets such as China, the Russian Federation, and Korea. However, the recent war between Russia and Ukraine may also negatively affect Latin American countries, not only in their coffee exports but also in the import of

fertilisers for coffee plantations. For example, Brazil imports about 85% of its fertiliser and about one-fifth of these imports come from Russia, so the country is currently looking for new fertiliser suppliers [92].

Aside from farmland, the agricultural machinery market is also expected to grow in the coming years. For example, in Argentina, this sector is expected to register a CAGR of 7.3% by 2027 [93].

4.3 Railway Domain

4.3.1 Short-term Market Analysis

Railway Market Overview

The railway sector is one of the fastest-growing sectors. At the end of 2019, rail transport had a record market value of €177 billion. Moreover, since 2017, the sector has experienced an annual growth of 3.6% due to the importance many countries give to the railway sector through investments in rolling stock, railway control and infrastructure. This growth and the investment made in this area are reflected in the number of kilometres of track in operation and the number of vehicles currently in service. Since 2018, the global rail network has expanded by 23.300 kilometres, and the number of vehicles has increased by 20.000 units [94].

Indeed, many cargo carriers that suffered from the uncertainty in container transport due to the pandemic turned to rail transport as an alternative freight option for trade routes between Asia and Europe. In 2021 alone, almost 1.5 million containers were transported between China and Europe. However, many of these trade routes from China transit Russia, Ukraine, and Belarus on their way to destinations in Western Europe [95].

The war between Russia and Ukraine has cast a slight shadow over the China-Europe rail service. Although trains passing through Ukraine account for only 2-3% of the total volume, sanctions against Russia have created uncertainty on the main routes passing through Ukraine [96]. The latest data suggest that shipping volumes decreased by about 24% in the westbound direction and 35% in the eastbound direction [97]. In addition, network equipment manufacturers, such as Zyxel Communications Corp, have stopped shipping from China to Europe by rail, hampering China's "Belt and Road" initiative [98].

Regarding the seismic movements in Turkey and Syria [4], how they will affect the transit of goods remains to be seen. Although it seems that their impact will be quickly overcome, in Syria, rail traffic was suspended, and it was decided that it was necessary to check the condition of the tracks. However, Syria does not play an important role on the international rail freight map. Turkey, on the other hand, does. It is a transit country for traffic coming from the east through Kars and heading towards Europe. This is the southern branch of the Middle Corridor. At the moment, the suspended services that have been announced are passenger services that connect the country’s west and east. However, the railway infrastructure in Gaziantep has collapsed [99]–[101].

Railway V&V and Testing Market Overview

The rail testing, inspection, and certification (TIC) market has great potential. At the beginning of the decade, this market was valued at USD 4.5 billion and is expected to grow at a CAGR of more than 2% over the next few years [102].

Within TIC segments, testing holds the largest share in the market owing to the stringent and government-enforced regulations, diverse product standards, increasing need for improved safety, growing industrialisation, and a need to protect the brand. All this will in turn result in a further boost in demand for TIC in the railway industry. In addition, increased focus by manufacturing companies to deliver quality products, growing demand for interoperability testing for connected devices and IoT to enable implementation of predictive maintenance, globalisation and increased world trade, and emerging digital technologies will further drive market growth [102].

However, this market also presents certain challenges, such as trade wars and growth fluctuations, a huge investment for automation and installation of industrial security systems, and the high cost of TIC due to various standards and regulations globally [102].

4.3.2 Long-term Market Analysis

Despite the negative impact that the coronavirus had on the sector, mainly during 2020 [103], the sector has been able to recover and is expected to grow at a CAGR of more than 4% between 2022 and 2030 [104], [105]. In this sense, the autonomous train market will become highly relevant, as it is estimated to grow at a CAGR of 5.1% from 2022 to 2030 reaching USD 12.3 billion by the end of the decade. Asia Pacific will lead this increase followed by Europe [106].

The radical evolution of the railway environment, driven by communication technologies, calls for an update of the current strategies and business models adopted by railway operators. The growing trend towards urbanisation and increasing electrification across the global transport industry, regardless of the mode of transport, has led to the development of automated transport methods, and trains have been at the forefront of transport automation after road transport. In addition, the growing need for efficiency and safety may drive existing rail operators towards automation. However, as the market is still nascent, the need for large investments in equipment R&D is expected to restrain market growth [107].

Once the project is completed, the expectations for this domain for the four markets covered by VALU3S are analysed below. The individual market analyses for the use case providers, SME/large organisation contributors, RTOs, and universities in the railway domain are presented in Appendix A.1.3, Appendix A.2.3, Appendix A.3.3, and Appendix A.4.3, respectively.

European Single Market

According to [108], the European rail market is expected to reach a value of USD 58.68 billion by 2027 owing to growing urbanization and government investments in the rail market. Although the war in Ukraine has this past year pushed Asia-Europe rail cargo back to sea and increased the growing queues of ships in ports [109], both the European rail freight market and rail passenger transport itself are expected to experience stable growth in the coming years [110], [111]. This will be due to several key

factors, such as increasing urbanisation, government investments in rail, and the initiative to create clean transport. Specifically, the EU has made funding available to support rail infrastructure projects, and countries have committed to projects that will improve and increase passenger rail services to relieve road traffic congestion, reduce emissions, and improve the sector's digital connectivity [112].

In addition, the EU is one of the leading countries in the rail sector, with the longest length of electrified track and one of the safest rail networks in the world, with some 218,000 km of active rail network [113], which is expected to expand with recent Western European investments in rolling stock in Germany and France.

Moreover, the rail supply industry (RSI) is an important component of industrial growth, employment, and innovation in Europe. The RSI includes the manufacture of locomotives and rolling stock, electrification, parts, and track manufacturing and signalling, as well as telecommunications equipment. The RSI employs some 400.000 people in Europe. The rail sector, including operators and infrastructure, accounts for more than one million direct and 1.2 million indirect jobs in the EU [114]. However, this is still far less than the 13.8 million jobs provided by the automotive sector previously mentioned [27]. On the other hand, European RSI invests 2.7% of its annual turnover in R&D representing 46% of the global RSI market. This investment in R&D is significantly reflected in the digitisation and development of innovative technology that makes it a globally competitive market. Automation, big data, and digital transformation of the supply chain are transforming manufacturing processes, creating benefits such as mass customisation, increased production speed, better quality, and higher productivity. This strategic goal will be reflected in 2030, when the EU will strengthen its position as a world leader in developing high-tech products and solutions [115], [116].

Finally, it is important to mention the main players operating in Europe’s connected rail market: Alstom, Bosch, Siemens AG, IBM Corporation and Atos Corporation.

European Market of Non-EU Member Countries and Neighbouring Partner Countries

Turkey has a strategic location between Asia and Europe and has become an alternative route for transporting rail cargo between the two continents as countries such as Ukraine, Russia, and Belarus have closed down [117]. Although the earthquakes have damaged the railway infrastructure in some regions of the country, this damage is not likely to last long and will not have a negative impact on the growth of the sector in the country. In fact, Turkey has been investing heavily in railways and rail technology for years, and new high-speed route construction, rolling stock, and further infrastructural upgrades are still expected [118]. A clear example is the Ankara-Izmir high-speed railway (HSR), built to connect the Turkish capital, Ankara, with Izmir, the third-largest city in terms of population and the primary Aegean port [119].

Technical and engineering expertise in the railway field has been improving, and local companies in Turkey have carried out very successful projects in advanced railway investments. This personnel qualification has led Turkey to be the eighth country in the world with the highest commissioning of high-speed rail operations. Furthermore, the introduction of high-speed rail technology has boosted efforts to develop advanced railway industry and create a domestic and national railway industry [120]. In the past, specifically before 2003, Turkey depended on the foreign railway industry. Today, however,

it is in a position where it can satisfy its own needs and is also an exporting country thanks to the investments it has made. This trend will increase in the coming years [121].

In Israel, there is a growing trend towards using public transport, such as trains and metros. Israel's population is expected to grow by about 5 million by 2040, and to respond to this significant growth, one of the strategic lines of the Israel railway domain is to invest in railway infrastructure. Major cities such as Tel Aviv, Jerusalem, Haifa, Nazareth, Ariel City, Rosh HaAyin, and Petah Tikva will see increased investment in the rail sector to develop several light rail transit (LRT), Metrorail, and high-speed rail projects. The LRT project involves the development of four lines, which together span 122 km and cover 181 stations. In the case of the Tel Aviv metro, construction is expected to begin in 2024. In this way, the government has shown its commitment to sustainable transport by continuing to invest in the planning and implementation of rail projects [122], [123].

Meanwhile, in 2020, the Serbian government planned to invest €3.5 billion in modernising the railway infrastructure as part of the Serbia 2025 programme [124]. Now, Serbia's railway network is undergoing intensive construction work.

Three major railway projects are being financed within the declared five-year strategy. €1.37 billion has been invested in the construction of the Belgrade metro and €1.5 billion in the other two projects related to the pan-European transport corridor X, which connects Austria and Hungary with Greece and runs through Serbia from north to south [125].

When the reconstruction is completed, the line's speed will be increased to 120 km/h. Travel time will also be significantly reduced, and the annual freight volume on the line is estimated to increase by 30% to 2.2 million tonnes per year. Axle loads will also increase to 22.5 tonnes, to weight category D4, whereas currently, loads are a maximum of 7.2 tonnes (category D3) [126].

When it comes to Croatia, the government is also investing in the implementation of large-scale infrastructure projects, such as the upgrading of the Krizevci-Koprivnica-State Border railway line, which involves the upgrading of a 42.6 km railway line between Krizevci, Koprivnica and the State Border, 702 km of Corridor Vc and several railway projects [127].

Russia and Asia

The Russian railway system, one of the world's largest, is strategically importance for the Russian economy. The railway sector in Russia is undergoing major development with several projects planned. As a result, Russia is expected to invest approximately USD 84 billion in railway projects by 2026 [128]. The two main strategic lines driving the Russian rail sector are freight transport and passenger transport through the creation of high-speed trains.

Considering population growth, a major expansion of the high-speed rail network and new high-speed rolling stock reaching speeds of up to 400 km/h are expected. High-speed rail projects are expected to have an average connectivity of 700 km, with projects aiming to link the Asia-Pacific regions. In addition, over the next 5-10 years, new deliveries of electric multiple units and electrification of passenger rail infrastructure are expected to significantly increase demand across the region [129].

However, it remains to be seen whether all these proposals or long-term projects can be successfully realised. To date, the West has hit Russia with a barrage of sanctions that, industry experts warn, is already leading Russia's rail industry into crisis, potentially the worst in modern times. More specifically, sanctions are having a major impact on Russia's ability to ship freight and move people across borders. However, indirectly they are hitting rail infrastructure too, with industry insiders suggesting manufacturing and maintenance are bearing the brunt, largely thanks to restrictions on importing materials and technologies [130].

On the contrary, Asia-Pacific is expected to register the fastest CAGR from 2022 to 2030 due to increasing government investments in constructing new railways and the high dependence of the population on rail transport. The autonomous trains segment will be among the fastest growing within this market. This is mainly due to the increased levels of automation and the demand for efficient and safe transportation [106].

In addition, Asian economies, such as China, India, and Japan, top the list of passenger-kilometres per year, with the main manufacturers in the rail market based in this region [113]. The most important country within this region is India, as the rail solutions market is expected to experience a CAGR of 13% by 2026 due to increasing traffic intensity and the complexity of the rail system, which requires real-time traffic control system [131].

India is also one of the largest and fastest-growing markets for railway components after China [132]. India is expected to be the fastest-growing country in the coming years. This growth is justified by its significant investments in recent years. In 2019, India had 716 km of metro lines in operation. At the beginning of 2019, the Ministry of Railways increased the allocation for the procurement, upgrading, and maintenance of rolling stock by 64% [133]. As a result, the Indian rolling stock market is experiencing steady growth thanks to upcoming metro projects (13 operational, 6 under construction, 7 in the planning stage, and 8 in the proposal stage) and the expansion of existing lines, and with the possibility of building a bullet train between Mumbai and Ahmedabad (Mumbai Ahmedabad High-Speed Rail Corridor) [134].

The Chinese rail market also plans to restore and develop the ancient Silk Road between China and Europe, encouraging investment in Eurasian transport and logistics, including rail networks, to boost Chinese investment and economic integration [134].

Latin America

Another region that will experience steady growth in the rail sector is Latin America. The Latin American freight, logistics, and rail market will experience growth between 2023 and 2027, where it is expected to register a CAGR of 3.36% during the forecast period [135]. The Latin American rail components and infrastructure market will generate around USD 7 billion within the sector by 2026 [136]. The increase in passenger and freight rail transport is inducing demand for rail infrastructure upgrades across the region. In addition, Latin America is focusing on high-reliability and high-performance trains at the lowest possible cost for its passengers, driving the market growth exponentially [137].

Within the region, Brazil's rail transport market will experience a dynamic increase in the next five to ten years; as the volume of raw materials for export will increase, it will stimulate an increase in demand for rail infrastructure construction to facilitate the connection of freight to major ports. The three major freight rail projects planned for the coming years are: Ferrogrão, Ferrovia de Integração Oeste-Leste (Fiol), and Ferrovia de Integração do Centro-Oeste (Fico). All three are eligible for certification as green projects by the Climate Bonds Initiative, a non-profit organisation that mobilises bond markets to promote investment in projects and assets needed for the transition to a low-carbon economy [138].

4.4 Healthcare Domain

4.4.1 Short-term Market Analysis

Healthcare Market Overview

The impact of coronavirus on the healthcare market was enormous and severely disrupted the entire healthcare supply chain, from raw materials to manufacturing and delivery [139]. In fact, many medical companies had to double their production capacity due to the high demand [140], and even strategic partnerships between healthcare and industry were formed to cope with such demand [141]. Even today, health systems continue to elevate the human experience of their staff and reshape what, how, and where they work, rapidly expanding virtual health services for patients and forging partnerships to produce and procure needed vaccines, treatments, and supplies.

The pandemic also highlighted the need to digitise healthcare and modernise healthcare systems in the absence of centralised, digital management. Thus, in the short term, a large outlay is expected from several countries to bridge this digital gap [142]. However, this should not be a major challenge, given that the healthcare market accounts for more than 10% of GDP in most developed countries, with North America and Europe being the continents with the highest revenues [143].

On the other hand, Russia's military offensive in Ukraine has triggered one of the world's fastest growing humanitarian and displacement crises, with geopolitical and economic repercussions across the globe.

The ongoing war has caused large-scale disruptions in health service delivery and a near collapse of the health system. But the crisis has also seen a mobilisation and response to a health emergency by World Health Organization (WHO) and its more than 100 partners. By delivering specialised medical supplies, coordinating the deployment of emergency medical teams, verifying and reporting attacks on healthcare, and working with health authorities, WHO and health partners have minimised disruptions delivering critical health services inside Ukraine and in countries hosting refugees [144].

These mobilisations by WHO and partners have also been notable in Turkey and Syria this last month. The organisation has deployed expert teams and flights with medical supplies to both countries in the aftermath of earthquakes that have claimed the lives of thousands of people [145], [146].

Healthcare V&V and Testing Market Overview

Just as the healthcare market is expected to grow in the coming years, so will the global healthcare testing services market [147]. Over the next two to four years, segments such as medical device testing and healthcare analytical testing are expected to grow at a CAGR of more than 5%. The harmonisation of standards, increasing consumption of medical devices in emerging countries, the growing need for V&V for medical devices, the imposition of stringent government regulation, the growing trend towards outsourcing of product testing and analytical testing services by pharmaceutical companies and the rise of clinical trials are just some of the key drivers in the next few years [148], [149].

4.4.2 Long-term Market Analysis

According to Verified Market Research [150], the global healthcare market is expected to reach USD 665.37 billion by 2028. By then, healthcare will focus on patients being able to prevent disease rather than seeking treatment. They will receive personalised healthcare solutions seamlessly integrated into their daily lives. All of this will be facilitated by data and algorithms and delivered within a health system that is organised and regulated in a completely new way [151].

This change will require transforming all parts of the current healthcare system and its complete digitisation. In addition, global public and private sector budgets are also expected to change. In fact, trillions of healthcare dollars will be spent differently than they are today. There will be less emphasis on treatment and care and more on prevention, diagnostics, and digital solutions, such as mobile apps, smart monitoring devices and AI-based analytics tools. Healthcare budgets in countries worldwide are expected to increase by a combined 10% by 2030. But some researchers' expectations put the figure much higher, at 42%. In contrast, spending per patient is expected to fall by as much as 28%. This is because the number of people accessing healthcare is expected to increase disproportionately to healthcare budgets [151].

However, a higher incidence is expected for diseases such as cancer and mental health. In particular, the latter is expected to generate the highest direct and indirect costs, estimated at more than 4% of global GDP, more than the cost of cancer, diabetes, and chronic respiratory diseases combined. In fact, by 2030, mental illness costs are expected to cause USD 6 trillion per year worldwide [142].

Once the project is completed, the expectations for this domain for the four markets covered by VALU3S are analysed below. The individual market analyses of the use case providers, SME/large organisation contributors, RTOs, and universities in the healthcare domain are presented in Appendix A.1.4, Appendix A.2.4, Appendix A.3.4, and Appendix A.4.4, respectively.

European Single Market

The European healthcare sector is expected to grow considerably over the next few years. This is reflected in four of the most important markets in this area, namely the medical devices market, the healthcare analytics market, the home healthcare market, and the digital health market, which are expected to grow at a CAGR of 4.09%, 19.4%, 8.4%, and 16%, respectively. Growth in these markets will be underpinned by the increasing ageing population, rising prevalence of chronic diseases, technological advances, increasing data recording in the sector, and growing demand for remote healthcare services [152]–[155].

Indeed, while recent government regulations and the authorisation of emergency kits are driving the growth of the medical device industry [152], information and communication technology in medicine is also gaining momentum, with mobile applications being widely used to improve health and lifestyle [155].

With the advent of digital devices such as IoT and apps increasingly becoming part of the healthcare system in Europe, various government initiatives to support and incentivise the use of technological solutions in healthcare further drive the demand for digitally-enabled clinical management [153].

European Market of Non-EU Member Countries and Neighbouring Partner Countries

Turkey, with a population of 83 million, is a growing market for the healthcare sector, especially for medical technology and healthcare services companies. For example, the Turkish medical device industry has grown rapidly over the last ten years, at a CAGR of approximately 17%, ranking third in Central and Eastern Europe with a value of USD 2 billion. This growth is expected to continue over the coming years, and now even more so with the two regulations released by the Turkish government, fully harmonised with EU legislation. These regulations aim to ensure high-level protection of the safety of patients and users, high-quality medical devices on the market, and a transparent, robust, and sustainable medical devices market [156].

In addition, the country has several strategic objectives that will significantly boost the market growth. On the one hand, Turkey wants to increase the country's skill set and know-how to manufacture medical devices instead of relying on imports. On the other hand, the country wants to foster the implementation of health IT in hospitals. In this regard, the Ministry of Health's "e-pulse" application allows citizens to access their medical records. Also, recently, applications have been developed to reduce diagnostic errors, telemedicine has been supported, and remote monitoring solutions have been developed to address the pandemic [157]. In addition, Turkish companies such as MLP Care have partnered with US companies to develop AI-based clinical solutions [158]. Given the benefits brought about by these targets described above, it is clear that this trend will continue to develop in the coming years.

Within the healthcare domain, the Israeli market is one of the major emerging markets in the Middle East, with a strong focus on health technology, research & development, and the advancement of medical infrastructure [159]. The country's healthcare market is trending towards a more integrated ecosystem, converging biopharma, medical technology, digital health, and healthcare into a single bioconverged sector. This bioconvergent field has provided Israel with many strengths and substantial capabilities to occupy a leading position in the healthcare market, with high economic value and the potential to become an additional growth engine for Israel's economy [160].

Medical devices, biotechnology/pharmaceuticals, diagnostics, health informatics (including telemedicine), and the "other" sub-sector remain the top five sub-sectors of the life sciences industry in Israel [161]. In particular, medical devices are the leading segment and are expected to grow at a 2.7% CAGR, from USD 1.5 billion in 2022 to USD 1.8 billion in 2028 [162].

Another of Israel's strengths is the cooperation it has with Australia concerning biomedical research. On the one hand, Israeli biotech companies are discovering the cost-effectiveness of Australia as a prime destination for clinical trials, providing opportunities for Australian biotech companies to work with

Israeli groups. This has generated access to new markets and a wider network of expertise and venture capital, focusing on solutions in medicine and cybersecurity, giving the two countries a competitive advantage [161].

In Serbia, the government is committed to improving and modernising the nationalised health system. In recent years, the government has undertaken an extensive programme of renovation and upgrading of equipment, with the help of external funding from international organisations such as the World Bank [163]. Over the next four years, this market is expected to grow significantly, showing a CAGR of over 15% and reaching a projected market volume of €71.03 million by 2027 [164]. Among the segments most likely to grow, the medical devices market stands out, which is expected to experience a strong increase in terms of sales. Regarding investment opportunities and product sales, the sector will offer strong growth prospects for domestic and international companies [165].

In Croatia, the healthcare market is also expected to grow in the coming years. Specifically, the latest data point to a CAGR of 7.6%, resulting in a projected market volume of €37.21 million by 2027 [166]. The current government has set a challenging target: to eliminate public hospital debt and improve the efficiency and quality of the Croatian public healthcare system.

In addition, the country has the potential to grow beyond the local healthcare market through medical tourism. Croatia is a popular medical tourism destination for dental, rehabilitation, orthopaedics, dermatology, and cosmetic surgery, with great growth potential. In addition, the improved regulatory environment, fully aligned with EU regulations, has allowed many newcomer manufacturers to enter the market easily and quickly [167].

Russia and Asia

Although humanitarian laws largely protect the supply of medical equipment, the medical device market will feel an indirect impact of international sanctions on Russia and will see potential shortages in 2023 as supply chain problems associated with the war arise. To compensate for this, Russia is expected to shift away from the West to rely increasingly on mainland China for medical device imports, as well as place greater emphasis on domestic medical device manufacturing [168]. In fact, according to the Deputy Health Minister of the Russian Federation, more than 30% of medical devices used are manufactured domestically [169].

In contrast, other market segments, such as healthcare analytics or home healthcare, could see significant growth in the future. As for the former, adopting AI on various platforms to deliver high-quality treatment services will drive the market growth rate [170]. Conversely, the latter could be the fastest growing market due to the increasing incidences of chronic diseases and growing demand for affordable healthcare delivery systems. In this case, the market is projected to reach USD 10.88 billion in 2030 [171].

In contrast, Asia Pacific will likely be the fastest-growing region by 2027 in the entire healthcare domain. The growing medical device industry and increasing demand for imaging and diagnostic equipment are expected to bolster the Asia Pacific medical devices market growth, which is expected to reach a value of USD 82 billion growing at a CAGR of 7.4% [172]. This growth will also be notable in Southeast

Asia, where increasing demand for accurate and early diagnostic methodologies will boost the market [173].

The healthcare analytics market will have high growth, expected to reach USD 5.2 billion by 2026 after growing at a CAGR of 19.23%. China and India will lead this market due to IT solutions. While China already holds a large market share, India is expected to register remarkable growth [174]. Furthermore, due to the ageing population in the continent and the rising of people determined to fight diseases like heart issues, diabetes, and different respiratory sickness, the home healthcare market is also expected to grow over the forecast timeframe at a CAGR of around 11.5% [175].

Finally, the digital health market will be the fastest-growing market, with a forecast CAGR of 21.2%. The increasing use of digital solutions to remotely secure patients' health during the coronavirus outbreak and the rise in the number of internet-enabled electronic devices and emerging lifestyle-related health issues will drive the growth of the digital health market in the region [176].

Latin America

As for the four medical markets analysed within the healthcare domain, in Latin America, all of them are also expected to grow at a steady CAGR. The medical device technology market is expected to grow at a CAGR of 5.79% between now and 2027, reaching USD 48.02 billion. This growth will be driven by the high demand in Latin American countries for technologies such as magnetic resonance imaging (MRI), ultrasound systems, x-rays, and mammography, where hospitals and clinics are betting on adopting workflow automation processes to ensure patient safety [177].

The healthcare analytics market is expected to grow most, reaching almost 20% CAGR between this year and 2027 [178]. Likewise, the home healthcare market will increase by around 10.43%. The reason for this is that according to the United Nations, the percentage of the Latin American population aged 65 and over will triple by mid-century, from 6.3% in 2005 to 18.5% in 2050. In addition, some Latin American nations, such as Brazil and Chile, could have more population than the United States. Accordingly, the demand for elderly care is expected to increase substantially [179].

Lastly, the digital health market is expected to progress healthily as well. This will be largely driven by the growing elder people population, rising obesity rate, and increasing usage of health apps for online medical appointments [180].

4.5 Aerospace Domain

4.5.1 Short-term Market Analysis

Aerospace Market Overview

The aerospace industry was probably the sector most affected by the pandemic [181], posing a significant challenge to revenues, earnings before interest and taxes, and cash flow for aerospace manufacturers and suppliers [182]. The decline in aerospace industry demand was reflected in airlines' and aircraft manufacturers' share prices, as were paraffin prices, while the price of WTI oil reached an all-time low. At the same time, the fall in prices impacted different aspects of the aerospace industry,

where international passenger capacity was reduced by more than 91% from the original plan, with Europe and Asia-Pacific being the most affected regions [183].

Now, in 2023, trends in commercial air transport and customer order activity are positive. Domestic traffic levels were around 81% of pre-pandemic levels in September last year, and international traffic levels have shown strong growth with the relaxation of travel restrictions worldwide [184]. With air transport volumes already well off the lows recorded in 2020, global commercial aerospace OEMs estimate that global passenger traffic will return to 2019 levels by late 2023 or early 2024.

However, the active war in Ukraine [3] could jeopardise this market recovery and growth. The Russian invasion of Ukraine has disrupted global supply chains and exacerbated fuel price volatility. This inflation remains a challenge for the sector. As passenger travel demand is correlated with ticket prices, which in turn depend on jet fuel prices, a rapid and sustained rise in jet fuel prices could affect traffic and increase market volatility [185].

In addition, the closure of Ukrainian airspace and the unavailability of Russian airspace for most airlines has led to a surge in diversions of long flights. Figure 4.3a and Figure 4.3b show the rerouting of international flights after the start of the war [186]. However, these diversions are still ongoing today. Figure 4.3c shows the flight route from London to Tokyo and its return in June 2022 [187]. On the other hand, Figure 4.3d shows the Great Circle route against the actual flight route of a plane from Luxembourg to Singapore this year, according to Flightradar [188]. These deviations, coupled with rising oil prices, may hit airlines' profitability hard. Therefore, the forecasts made may be slightly affected due to the war.

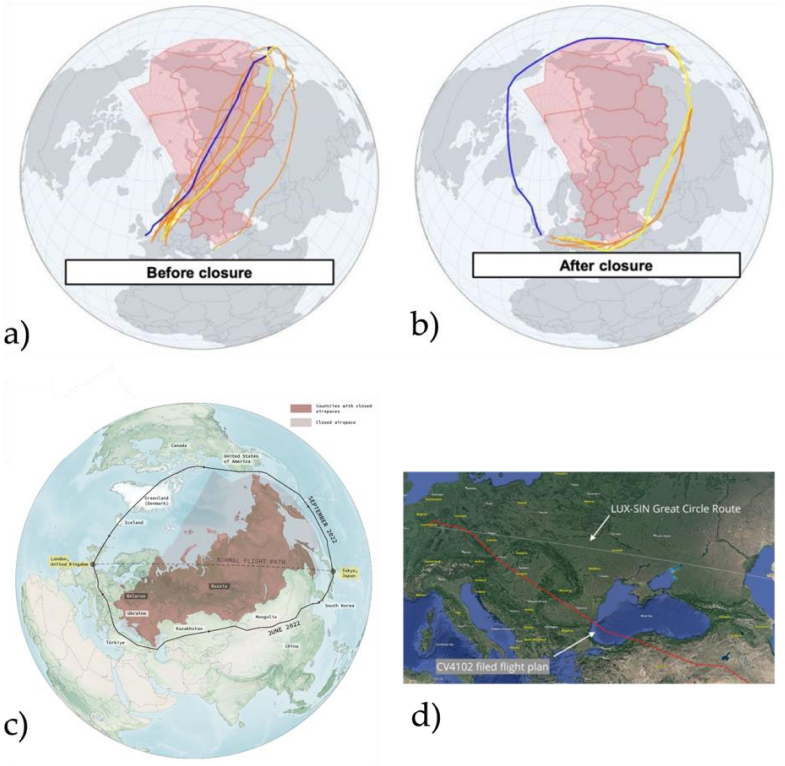


Figure 4.3. Diversion of international flights due to the closure of Ukrainian and Russian airspace as a result of the Ukrainian war [186], [187], [188].

Aerospace V&V and Testing Market Overview

The future of the global aerospace testing market looks promising in both the short and long term, expecting an increase at a CAGR of more than 4% from this year to the end of the decade [189], [190]. This increase is driven by emerging opportunities in space exploration and major industry players' increasing investments for research and development activities.

Although aircraft V&V testing includes business jets, helicopters, or military aircraft, commercial aircraft constitute the largest market segment, and non-destructive testing is the primary testing method. These tests focus mainly on evaluating new materials and compliance with stringent aviation regulations and certification standards for aircraft safety [191].

4.5.2 Long-term Market Analysis

Despite the socio-economic events of the last three years that have hampered the growth of the aeronautical sector and continue to do so today, the industry's predictions are promising thanks to the investments and technology evolution expected to take place over the coming years. In this regard, the aerospace market is expected to reach over USD 430 billion within two years growing at a CAGR of over 7% and another 5.9% annually until 2030 to a total of USD 573.6 billion [192], [193].

The market growth will be driven by factors such as the booming commercial aircraft segment, increasing global air traffic, and rising military spending. Therefore, the market trend in the aerospace industry is particularly focused on advancing technology and innovation, using different manufacturing materials, and decreasing fuel consumption and aircraft emissions due to the increase in oil prices. For example, aircraft manufacturers are using machine learning techniques, such as AI, to improve aircraft safety and quality, as well as manufacturing productivity. In addition, these technologies optimise manufacturing operations and reduce costs [194]. One example is GE Aviation, which uses machine learning and data analytics to identify engine failures, increase component life, and reduce maintenance costs. Boeing, meanwhile, has successfully created machine learning algorithms to design aircraft and automate factory operations.

Once the project is completed, the expectations for this domain for the four markets covered by VALU3S are analysed below. The individual market analyses for the use case providers, SME/large organisation contributors, RTOs, and universities in the aerospace domain are presented in Appendix A.1.5, Appendix A.2.5, Appendix A.3.5, and Appendix 0, respectively.

European Single Market

Despite the ongoing war in Ukraine [3] and market volatility, according to [195] and [196], both the European aviation market and the aerospace parts manufacturing market are expected to grow at a CAGR of more than 5% over the next years. In this regard, one of the segments in which European North Atlantic Treaty Organization (NATO) countries expect to make the largest expenditures is on their military aircraft fleets as a result of the war [197].

In addition, the aviation industry is an important strategic line of business for the EU, contributing €300 billion (or about 2.1% of GDP) to the European economy before the coronavirus pandemic, as well as supporting some 5 million jobs [198]. Within this strategic line, the EU's strategic objectives are the

growth of the European aviation industry, investment in R&D and innovation, and the development of safer, cheaper, and better-quality flights for passengers. At the same time, the EU, through the European Green Pact, aims to reduce carbon emissions by 2050, creating a transition to a greener and more environmentally friendly industry [199]. The 2011 Flightpath 2050 vision sets out key research policies to be achieved by 2050, including how to preserve Europe's global leadership in the sector and reduce carbon emissions by 75% by mid-century. In addition, Horizon 2020 is one of Europe's points of strength in driving aviation research to achieve these goals. One example is the Clean Sky Enterprise [200], a public-private partnership between the EC and the European aeronautics industry that coordinates and funds projects to achieve much quieter and greener aircraft.

Within this industry, the most important companies are Airbus SE (France), Leonardo SpA (Italy), and Dassault Aviation SA (France), although the United Kingdom is currently the largest market in the European region.

European Market of Non-EU Member Countries and Neighbouring Partner Countries

The Turkish aerospace industry is expected to grow at a steady CAGR of more than 5% until 2028. On the other hand, this growth will be driven by the country's growing demand for passenger traffic, which is leading the development of new commercial aircraft by airlines such as Turkish Airlines, SunExpress, Pegasus Airlines, Onur Air, Corendon Airlines, and Anadolujet. On the other hand, the government announced plans to increase exports in the aerospace industry, where the Middle East and multiple European countries are expected to be potential buyers of Turkish aerospace parts [201].

Moreover, leveraging the role of Turkish drones and fighters in bolstering Ukrainian defence in the war between Ukraine and Russia, NATO lifted restrictions on the country's military sales late last year. These restrictions were imposed after the Nagorno-Karabakh war in 2020, in which Turkey supported Azerbaijan against Armenia, leading to the scrutiny of Bayraktar drones. With the lifting of these restrictions, Turkey regains the ability to export aerial military weaponry [202].

Another of the country's strategic goals is a commitment to local design and production, which has created dozens of local programmes, such as drones, helicopters, training aircraft, and an ambitious programme to build a fighter jet locally [203]. The Turkish government proposes to restructure its defence export incentive system to achieve these goals. In addition, it will launch a government-to-government sales scheme to promote defence exports in 20 countries.

Israel is one of the pillars of the aerospace industry, as it is at all stages of the global value chain, from aircraft component manufacturing to advanced electronic systems and the development of precision metal components. For example, Israel is a world leader in producing unmanned aerial vehicles (UAVs) with advanced space launch capabilities. In addition, Israel stands out mainly for the advantages it offers in fields such as low-cost but high-quality manufacturing for Western countries, innovation, and entrepreneurship producing advanced technologies (UAV automatic landing and take- off), and expertise with the use of advanced technologies and aerospace defence products [204].

Despite the remarkable impact of the pandemic on the country's industry, the latest Research and Markets report predicted at the end of last year that the Israeli aerospace and defence industry would grow at a CAGR of 5.9% until 2026 [205]. Furthermore, it is worth noting that the war between Russia

and Ukraine has caused multiple European countries to rush to buy arms, which in turn has caused the shares and profits of several Israeli aerospace arms companies to soar [206]. These companies have a diverse portfolio of products and services, including space and aerial reconnaissance systems, radar systems, unmanned aerial vehicles and avionics systems. They produce structural components and parts and operate maintenance, repair, and upgrade facilities [207].

As for Serbia, Air Serbia, the national carrier, is expected to return to pre-pandemic levels this year, as its passenger performance and average cabin occupancy rate exceeded the industry average in Europe in 2021. As a result, the carrier plans to undertake a phase of continued growth as the leading regional airline, launching six new routes of public interest and renewing the fleet with cutting-edge ATR aircraft [208].

Croatia's air transport sector makes a major contribution to the country's economy. In 2018, it was estimated that, between aircraft manufacturers and air navigation service providers and the purchase of goods and services from local suppliers, the sector employed around 13.000 workers in the country. In addition, the air transport sector, including airlines and their supply chain, was estimated to produce a GDP for Croatia of USD 456 million. Therefore, it was estimated that air transport in Croatia could grow by 66% in the next 20 years under the "current trends" scenario. This could be dampened by the impact of the coronavirus. However, this would mean an increase of 3.4 million additional passengers by 2038, which, if fulfilled, would support about USD 2.2 billion of GDP and about 37.340 jobs [209].

Russia and Asia

Although the Russian aerospace industry is one of the driving forces of the country's economy and the one that invests the most in science and technology [210], this sector could be one of the hardest affected by the war between Russia and Ukraine [3]. In fact, many foreign airlines stopped operating and maintaining their fleet in Russia last year. For example, according to data published by Cirium, an aviation data analysis company, there are some 332 Boeing aircraft among the Russian airline fleet of 861 aircraft currently in service, so the withdrawal of Boeing's technical support to Russian airlines may have a negative impact on the sector not only in the short but also in the medium term [211]. Moreover, the fact that airlines stopped operating in the country has also impacted the maintenance of the fleets, with a significant reduction in the supply of aircraft parts. In addition, China has refused to supply these parts to Russian airlines, so the country is currently looking for opportunities to source parts from countries such as Turkey and India [212].

Similarly, the number of daily flights in Russia has declined rapidly. According to a report published by the Chinese flight-tracking platform Feichangzhun [211], on 24 February last year, when the military war in Ukraine began, the number of daily take-offs and landings fell by 19% compared to the usual level. Already two years ago, with the coronavirus pandemic [2] and the current Western sanctions, the Russian aerospace market could falter and not fully recover for a few years.

Chinese airlines, by contrast, have been relatively less affected by the Russian and Ukrainian airspace closures, at the moment, than their European counterparts. This is mainly because flights operated by Chinese carriers can fly to Europe over Russian airspace [213]. However, the country's current zero-COVID policy is causing significant volatility in the sector's economic activity levels [214].

These current socio-economic issues aside, the size of the market in China is expected to increase by USD 1.2 trillion by 2038 [215]. The International Air Transport Association (IATA) estimates that China will be the world's largest aviation market by 2024, surpassing the US aviation market. According to the report, by 2038, the demand for civil aircraft in China will exceed 8.000 units, and the size of the civil aircraft market will increase by USD 1.20 trillion. As Chinese companies can only manufacture a small number of regional aircraft and cannot develop and manufacture conventional aircraft, China relies heavily on imports of civil aircraft, with the largest imports coming from Boeing (US) and Airbus (Europe). As a result, China will become one of the most important markets for global aircraft manufacturers, aircraft parts manufacturers, and aircraft leasing companies. Another growth driver is passenger traffic and the need to meet the demand and alleviate the actual capacity pressures. In this regard, China plans to build new airports in cities such as Dalian, Chengdu, and Xiamen this year and nine new runways at existing airports such as Shanghai and Shenzhen by 2030 [216]. Lastly, it is important to mention the government's "Made in China 2025" plan [217]; if an aircraft part is made in China, all minor components of the unit must be manufactured and supplied by Chinese companies. The economic plan states that by 2025, 100% of all parts must be developed by Chinese companies. The ultimate goal of this plan is for Chinese manufacturers to be among the top 10 in the world by 2035 and the top 5 by 2045.

Latin America

According to [218], the Latin American aviation market is expected to grow at a CAGR of over 5% from 2023 to 2028. The coronavirus outbreak [2] had a major impact on the Latin American aerospace industry; however, demand for domestic travel and cargo movements and the growth of low- cost carriers in the region are acting as the main drivers of the market's revival. In addition, the easing of travel restrictions has led to a pick-up in passenger flows within the region and to North America, which in turn has contributed to the recovery of passenger traffic in the region [219]. According to the latest data from the Latin American and Caribbean Air Transport Association (ALTA), by the middle of last year, the Mexican market had already surpassed the level of activity of 2019, and other countries, such as Brazil, had recovered 90% of its domestic market [220].

This growth in the aerospace market is also influenced by the presence of Latin American aircraft manufacturer Embraer, which is based in Brazil. In addition, Brazil has the largest business jet fleet in Latin America and the second largest business jet fleet in the world [218].

Over the coming years, Latin America’s aerospace and aviation sector will be underpinned by different strategic lines. On the one hand, the improvement of general aviation safety. The fact that air transport has become safer due to the introduction of improved safety standards has led to an increase in the purchase of general aviation aircraft in the region. On the other hand, another priority is the modernisation and creation of new airports, where airport infrastructure improvements can potentially impact the general aviation market in the coming period. Finally, Latin America has a high demand for helicopters. São Paulo, with 500 registered helicopters and 700 daily flights, has the largest helicopter fleet in the world [221]. The fleet is expected to grow in the coming years, mainly due to road congestion and the fact that those who can afford to travel by helicopter are opting for helicopters for commercial operations [218].

On top of this, the continent plans to modernise its military aircraft fleet to bolster its armed forces. This is expected to further boost the continent's aviation sector during the forecast period [219].

4.6 Industrial Robotics/Automation Domain

4.6.1 Short-term Market Analysis

Industrial Robotics/Automation Market Overview

The economic downturn caused by the coronavirus outbreak [2] also severely affected the robotics sector. In fact, in 2021, the global industrial robotics market declined for the second year in a row after three years of steady growth [222]. However, last year's forecasts were again positive, and the market was expected to trend upwards again, increasing its value from USD 24.35 billion in 2020 [223] to USD 33.75 billion by the end of 2022 [224].

This year's reports, however, suggest that those predictions were too conservative, with the latest results pointing to the global industrial robot market being valued at more than USD 40 billion in 2022 [225]. According to the new World Robotics report [226], this is due to the all-time high number of new industrial robots installed in factories around the world, which has surpassed the pre-pandemic record of robot installation.

One of the key factors driving the growth of the global robotics technology market is the large number of investments and funding in the technology field. According to the International Federation of Robotics' World Robotics report, the demand for robots has been boosted by investments in new vehicle production capacities and the modernisation of industrial facilities. Another significant factor has been the increasing use of service robots around the world, such as cleaning robots [227].

The robot technology industry offers attractive potential due to Industry 4.0, the recently introduced Industry 5.0 paradigm [228], and regional digitalisation initiatives. Given the number of robotics trade exhibitions taking place in different areas on a regular basis, large organisations are expected to make collaborations and business expansions with new entrants focusing on modernising technologies and services [227].

Industrial Robotics/Automation V&V and Testing Market Overview

Although the automation testing market encompasses devices and software other than robotics, it was valued at USD 24.7 billion in 2022. Testing is an important component of the software development lifecycle process. Dynamic delivery is necessary to have testing resources on demand. The automation testing platform has proven to be a valuable tool for data management and time consumption, which can be scaled up or down based on customer needs and requirements, offering great scalability [229].

However, the automation testing market faces a challenge which, in turn, can become an opportunity for those organisations that know how to exploit it. Currently, this market has a high shortage of skilled automation testers, especially in the agile development lifecycle, which can limit continuous focus, delivery frequency, and overall customer satisfaction. In this regard, testers are expected to be technically skilled to participate in various interactions between teams and automation technologies in

agile development. In addition, the shortage of test environments and test data specialists further exacerbates this demand. As such, these services are expected to be highly sought after in the coming years [229].

4.6.2 Long-term Market Analysis

According to [225], the global robotics market is expected to reach USD 75 billion by 2026. This growth will also be followed by the automation testing market, projected to grow from USD 24.7 billion in 2022 and USD 52.7 billion by 2027 at a CAGR of 16.4% [230]. The automation of manufacturing processes through robotic systems is changing the way production systems, in general, are conceived. The widespread adoption of robots in the food industry, the increasing use of collaborative robots in the workplace, and the growing popularity of AI solutions represent a reliable alternative technology for the development of flexible and reconfigurable manufacturing systems to solve different production tasks.

Once the project is completed, the expectations for this domain for the four markets covered by VALU3S are analysed below. The individual market analyses of the use case providers, SME/large organisations contributors, and universities in the industrial robotics/automation domain are presented in Appendix A.1.6, Appendix A.2.6, Appendix A.3.6, and Appendix A.4.6, respectively.

European Single Market

While European countries such as Germany, France, Italy, and Spain were among the hardest hit by the coronavirus outbreak, this bump recovered by 25% by the end of 2021 [231]. Indeed, the European robotics market is expected to grow at a CAGR of 5.8%, resulting in a market volume of USD 14.96 billion by 2027 [232]. This is mainly driven by the labour shortage in the European region and the implication of automation and AI in this market, where the automotive sector is one of the main demanders, as it includes robotics in its entire assembly line.

The German industrial robotics market is the largest in the region, with 38% of European industrial robots operating in German factories and employing almost one million people, followed by Sweden and Denmark [233]. Therefore, the German country hosts Europe's leading robot manufacturers. These include KUKA (Germany), Rethink Robotics (Germany), b+m Surface Systems (Germany), Franka Emika (Germany), Universal Robots (Denmark), Comau (Italy), CMA Robotics (Italy), IGM (Austria) and ABB (Switzerland).

Manufacturers strive to reduce the operational cost of processes, which can be achieved by reducing errors in the operational workflow and reducing material waste, not only in the automotive sector but also in the electrical and electronics industries. In this context, manufacturers are applying robotic solutions to reduce these operational costs, ultimately increasing manufacturers' profitability, and improving operational flexibility. In fact, the European Commission itself advocates robotics as a strategic line in the digitisation of the region through its Horizon Europe programme [234]. Robotics, therefore, presents great opportunities for the future, offering new business and employment opportunities.

European Market of Non-EU Member Countries and Neighbouring Partner Countries

In recent years, the Turkish government has launched a drive to transform the country's economy into a knowledge-based system. It aims to develop intelligent products with high added value that impact, among other areas, the automation of certain processes. In this sense, Turkey plans to make a big leap in its robotic systems to follow the global trend in which smart manufacturing and automation are gaining importance within the industry [235]. According to [236], the Turkish robotics market is expected to show a CAGR of 3.24%, resulting in a market volume of USD 396.4 million by 2027. Specifically, this market potential is influenced by two of Turkey's leading sectors, automotive and food, where the automation of various processes through robotics is becoming more and more noticeable [237].

A report by the Turkish Informatics Foundation in 2019 indicated that 50% of manufacturers in Turkey planned to invest in Industry 4.0 in the next 3 to 5 years, 20% had no strategy yet, and the remaining 30% planned investments in 5 to 10 years. Also, in a 2018 survey conducted by the Scientific and Technological Research Council of Turkey, the technologies that Turkish SMEs considered most important for their industry were automation and control systems, advanced robotics, and additive manufacturing [238].

Concerning Israel, its robotics companies are growing at a high rate [239]. 4% of the high-tech sector is currently dedicated to this industry, which is expected to increase considerably in the coming years [240].

Thanks to its entrepreneurial culture and innovative ecosystem, the country is already fully immersed in Industry 4.0, with more and more companies opting for automation technologies. In fact, in the context of venture capital investments in Industry 4.0 start-ups, Israel has ranked third, behind only the United States and China, in the last 5 years [241]. This position is expected to be maintained with increased investment in the robotics industry in the coming years.

As far as the two Balkan countries analysed in this document are concerned, Serbia joined the Centre for the Fourth Industrial Revolution Network last year. In this way, the country will shape the development of Industry 4.0 strategies in the years to come, where it will collaborate with key national stakeholders, such as the National Institute for Artificial Intelligence and other governmental and private sector institutions. This is the first Centre for the Fourth Industrial Revolution Network in the Balkan region, and major breakthroughs are expected in AI and machine learning, IoT and robotics, 3D printing, nanotechnology, and biotechnology, among others [242]. When it comes to Croatia, the country has seen the emergence of a slew of high-tech champions in the fields of IT software and hardware. Specifically, in robotics, the AI start-up Gideon Brothers raised a USD 31 million Series A investment in a round led by Koch Disruptive Technologies, the venture and growth arm of Koch Industries, in 2021. Gideon plans to use the funds to accelerate the development and commercialisation of its AI and 3D vision-based autonomous mobile robots. It will also expand its manufacturing, sales, marketing, and customer service operations across key markets in the EU and the US by opening offices in Munich and Boston [243].

Russia and Asia

Russia is not usually associated with the use or manufacture of robots. However, its low density of industry robots indicated great growth potential a year ago. The Russian Association of Robotics (RAR) predicted significant growth in robotics adoption over the next five years. This was mainly due to five trends that indicate this could happen. The first was the government's intention to drive the development and application of digital technologies, including robotics. The second was the booming demand for educational robotics. In fact, in 2017, the education sector was the largest adopter of service robots in Russia, accounting for 31% of service robots sold by the top 10 service robot companies tracked by RAR. Third, Russian robot manufacturers had set their sights on the service robot sector. Fourth, there was a growing market for industrial robots and finally, Russian robot suppliers were focusing on developing applications and business models for SMEs to invest in robots [201].

Despite the sanctions packages in the context of the military operation in Ukraine [3] and the closures of several automated plants that led to a decline in technology imports such as electronics and industrial robots into the country [244], predictions about the growth of the robotics market in Russia seem to be holding steady. According to [245], the market is expected to grow at a CAGR of 3.30%, resulting in a market volume of USD 328.1 million by 2027. These predictions could be sustained due to several factors. First, large industrial robot developers are in no hurry to leave Russia. While multinational European companies have closed their plants across the country, other brands such as KUKA continue to have their national offices in operation since June last year, and for the time being, their management has no plans to lay off employees or close their country office. On the other hand, the Russian government is boosting the acquisition and use of industrial robots. At the end of last year, the prime minister signed a government decree adding manufacturers of industrial robots and robotic devices to the programme of subsidies to the machine tool industry. This year, the Kremlin also approved the federal project for the development of national robotics, defining, among other things: legal, fiscal, and other conditions for the development of production and deployment of industrial robots in the Russian Federation. Among its objectives, it is expected to ensure an annual reduction in the backlog of such robots by 10.000 production workers in the country compared to the world average over the next years [246].

In contrast, Asia is expected to record the highest growth rate by 2026. Both Asia Pacific and Southeast Asia are expected to grow at CAGRs above 10% [247], [248]. In this regard, China dominates the regional adoption rate of robotics due to the massive deployment in the country's electronics and automotive sectors. Moreover, as these sectors are developing at a high rate in other regional economies, such as India, there is great potential for growth in the market under study [249]. In fact, India has already started marketing its own brand of robots [250]. With sales increasing by 200% annually, its plan for industrial robots manufactured and designed entirely in India appears to be on the rise, and it is expected that these robots will be able to compete with foreign robots and impact India's new automation market by 2025 [251].

Increasing investments by major industrial players in Asia-Pacific countries and growing government support are other key factors responsible for the growth of the industrial robotics market in Asia-Pacific. In addition, offshoring of production to reduce costs in the manufacturing industry and rapid digital transformation of the manufacturing industry through industrial IoT are encouraging the use of these

technologies. This, together with the presence of some of the most technologically developed countries (Japan, China, and South Korea) and their respective robot manufacturers, Siasun Robotics (China), Yaskawa (Japan), Fanuc (Japan), Nachi-Fujikoshi (Japan), Hyundai Robotics (South Korea), among others, means that Asia will be the leading continent in robotics in the coming years.

Latin America

The increasing global adoption of industrial robotics across industries is expected to create significant growth opportunities in the Latin American region. In fact, this region is among the fastest-growing sectors for industrial robotics in the world. This is because players in this market are increasingly investing in robotics and automation to improve operational efficiency and reduce costs, especially in the steel and automotive industries, due to the need to modernise production facilities and automation. The development of skilled labour has also spurred investments in automation, driving market growth [252].

According to the latest report from Research and Markets [253], Latin American industrial robots' market is expected to grow at CAGR of 9.21% between 2021 and 2028. In particular, this growth will be most notable in Brazil, where already last year, the Brazilian industrial robotics market was expected to be the largest market in Latin America, generating around USD 36 million, with the total Latin American market reaching USD 374.4 million [254]. Brazil is also expected to be joined by Argentina and Chile. In Argentina, the government has encouraged investors by enacting laws that benefit start-ups and technology businesses. This has led to an increase in the number of companies employing AI, machine leadership and robots. In addition, federal grants and regulations can help companies advance their product offerings, in turn meeting the growing demand for robots. Meanwhile, Chile is focusing on robotics and AI to improve productivity across multiple industries. In addition, other international players are establishing commercial operations in the country, which will increase the adoption of robots [253].

On the other hand, as in Asia, due to the offshoring of certain production activities to emerging economies, deploying collaborative robots is a good strategy for companies looking to improve productivity and increase the efficiency of fulfilment operations [255].

4.7 Market Risk Assessment

During the course of VALU3S, the trends in the markets of the domains worked on in the project, as well as the inflation, have been highly disrupted. These changes have brought about by the coronavirus pandemic [2], the war in Ukraine [3], or the recent natural disaster in Turkey and Syria [4]. As a result, the market trends analysed in this document may, therefore, vary again depending on the socio-economic events that may occur. In order to forestall these possible eventualities, a brief market risk analysis to mitigate potential erroneous forecasts in the long-term market analyses is presented below.

Generally, a market risk assessment is divided into an external and an internal risk analysis (Figure 4.4). However, due to the multiple types of organisations that make up the VALU3S consortium, as well as their target markets, internal risks are outside the scope of this market risk assessment. Therefore, only those external risks, which could shape the evolution of the markets, are included in Table 4.1.

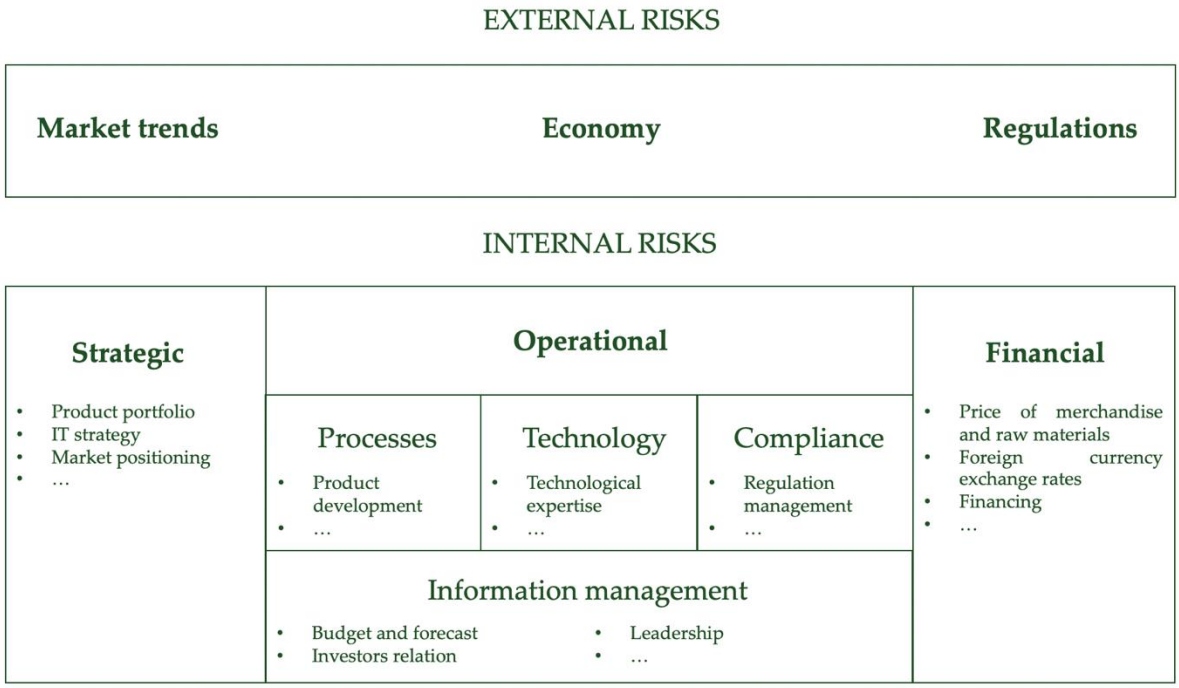


Figure 4.4. Market risk assessment framework.

Table 4.1. Market risk assessment.

Risk	Level	Outlook	Mitigation measures
COVID-19 residual uncertainty and ongoing impacts.			• Reduce dependence on a single supplier. • Expand the manufacturing network. • Consider new operating strategies. • Try to acquire new customers. • For more information, refer to [256].
Ongoing uncertainty from Ukraine war, risks of market volatility and market shifts.			
Reduced growth increasing already high indebtedness from the pandemic and higher debt refinancing costs weakening public and private balance sheets.			• Rent rather than buy equipment. • Agree payment terms in advance. • Seek out grants and supports. • For more information, refer to [257].
Macro-financial headwinds related to the tightening of financial conditions globally and recession risks.			• Improve customer satisfaction. • Refocus business opportunities. • Move costly initiatives to the back burner. • Make a list of cost-saving options. • Investigate key person assurance. • For further information, refer to [258].

Risk	Level	Outlook	Mitigation measures
Ongoing high short-term operational risk of cyberattacks, especially from Russia.			• Conduct a cybersecurity risk assessment. • Establish network access controls. • Implement firewalls and antivirus software • Create a patch management schedule. • Continuously monitor network traffic. • Build an incident response plan. • Examine the physical security of the business. • Minimize the attack surface. • For further information, refer to [259].
Increased market volatility and higher inflation increase short-term risks for consumers, especially losses from negative real returns.			• Leverage ongoing partnerships. • Consider prices increases, but only from a rigorous fact base. • Seek win-win negotiations. • Develop flexibility in product development and manufacturing. • For more information, refer to [260].
Risks of aggressive marketing, especially of higher-risk structured products due to loss of customers during the pandemic.			• Focus reactive price cuts on only those customers likely to be attracted by the competitor's offer. • Focus reactive price cuts on a particular geography, distribution channel, or product line. • Differentiate the product by increasing the value of the offer. • Build barriers to competitive. movement into the less price-sensitive, more profitable customer segments. • For more information, refer to [261].
Changes to international trade policies and costs.			• Diversify the supply chain by spreading orders over several suppliers. • Have a system of fail-safe measures that include having a backup supplier for every existing supplier. • Hire a commercial lawyer. • Consider working with the Multilateral Investment Guarantee Agency.
Level: High risk  , medium risk  , low risk  .		**Outlook**: upwards  , stable , downwards  .	

Chapter 5 Life after VALU3S

This chapter compiles a set of initiatives and concerns over how to prevent the overall project results from losing their interest by the community and falling into oblivion once the VALU3S project reaches its completion. The motivation for keeping the project results "*alive*" is manyfold, including:

- The partners involved in VALU3S increase the visibility of their work and skills, consequently increasing their reputation in the field.
- The funding authorities that supported VALU3S acknowledge their investment, gathering long-term visible results.
- The community of SCP for Cyber Physical Systems (CPS) is enriched with longer-lasting contributions.

5.1 Keeping the Results Alive

Our approach to keep project results visible consists of identifying targets, activities, and aspects (see Figure 5.1) that should be addressed to facilitate the preservation of the results and predicting measures that can or should be taken in this process. The eventual goal is that the project can be seen as worthwhile and a benchmark for the coming years. What these three elements (targets, activities, and aspects) are and how they have been structured is explained below.

Figure 5.1. Overview of our approach: how to structure elements to be preserved.

5.1.1 Targets and Activities

Both targets and activities are mapped to sections and subsections of this chapter, indicating results that should be preserved, and tasks that need to be performed, respectively. This structure is summarised in Figure 5.2, reflecting the structure of this chapter. Example targets include the project website and the web-based repository, while example activities include the operation of the associated technologies, or the maintenance of their content.

Each section and subsection start with an introduction explaining what it is about, and a possible relation with other section/subsections.

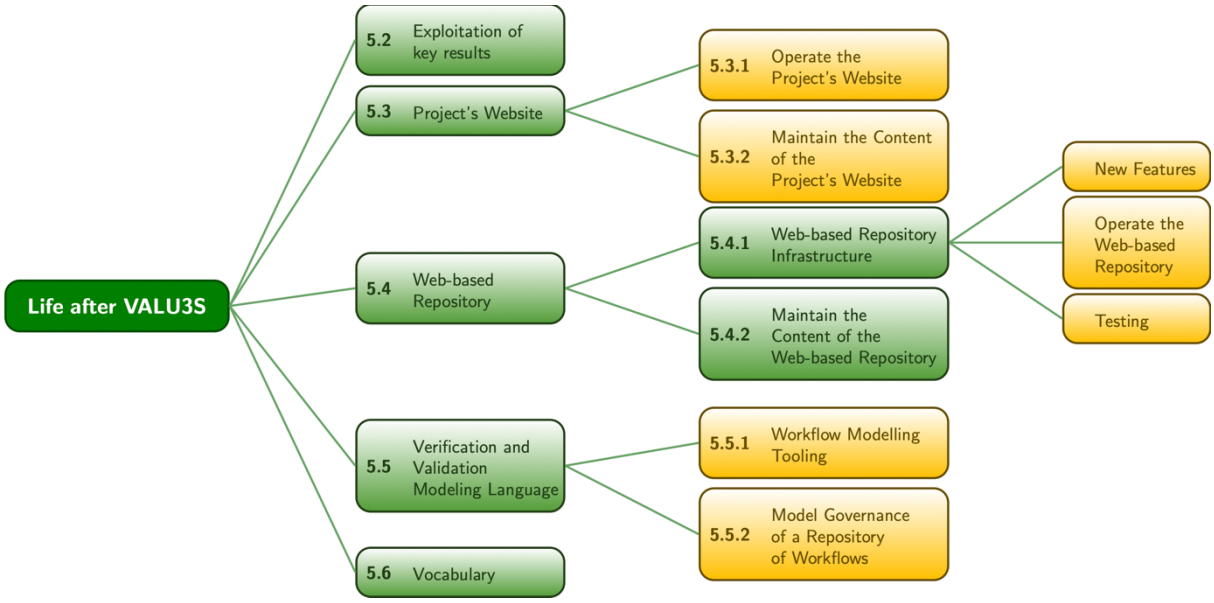


Figure 5.2. Structure of this chapter, where sections and subsections are either targets (green) or activities (yellow).

5.1.2 Aspects

For each target and activity, we evaluate a set of *"maintenance and growth aspects"*. A list of such aspects that are used are compiled in Table 5.1.

Table 5.1. Core maintenance and growth aspects considered throughout this chapter.

Aspect	Description
Benefit	Captures what are the core benefits for all partners, and benefits for the general community.
Incentive	Captures what are the incentives given to the partner/person who is responsible of the activity.
Moderation	Describes how the moderation process is applied, whenever applicable.
Content Quality Assurance	Describes the approach taken to increase trust in the content, e.g., introducing a new editorial board.

Aspect	Description
Presentation Quality Assurance	Describes how to maintain or improve the layout or structure of the elements used by the target or activity.
Service Quality Assurance	Describes how to maintain or improve the offer/consultancies provided.
Promotion	Captures how the activity or target is disseminated.
Other Social Media Platforms	Captures all platforms and ways of dissemination not covered by 'Promotion'.
Consolidation	Captures which elements are maintained and kept up to date.
Organisational Structure	Describes the management roles that should legally comprise a potential company.
Technology Notes	Describes technical aspect that can be relevant for the activity, such as the concrete infrastructure tools.
Legal Aspects	Describes core legal aspects that should be considered, or proposes legal actions that should be taken, including IPR.

5.2 Exploitation of Key Results

A potential approach to exploit VALU3S key results could be the creation, after the end of the project, of an Ecosystem of Services. This Ecosystem should be capable of addressing the needs of several customers from many domains through the use of tools, methodologies and competencies developed within the project. These tools, called here the *VALU3S toolbox*, include the web-based repository and the V&V-centred systems engineering tool suite. This Ecosystem has been mentioned both in the original proposal and in the final delivery on the exploitation plan (D6.13 [5]). It would provide customers with tailored holistic solutions thanks to the possibility of accessing to a wide set of validated tools and combining them, as well as relying on the cooperation among partners with complementary competences.

The legal entity of the Ecosystem could be a dedicated spin-off company, involving several consortium partners, in charge of managing the marketplace and providing the above-mentioned services. This company could be a European company, created based on the European Company Statute, which would allow:

- To manage the business in a simpler way being active in more than on EU country.
- Greater mobility in the European market.
- A framework for how to involve staff (employed in more than one country) in the running of the business.

The aspects of this target are presented in Appendix B.1.

5.3 Project's Website

The project's website is currently accessible at https://valu3s.eu. This section describes challenges and approaches to maintain this website after the end of the VALU3S project.

The web-based repository is covered in Section 5.4. It is also accessible online, currently available at https://repo.valu3s.eu/, and it covers complementary topics, focusing on the methods and tools developed within VALU3S. The project's website should keep updated references to entries in the repository, and the two websites can be possibly (partially or fully) fused into one.

The overall aspects of this target are presented in Appendix B.2.

5.3.1 Operate the Project's Website

Operation captures the efforts to keep the website operating and reachable. This includes paying for the domain name and security certificates (if not free), either renting or providing web space (hosting), and ensure that the web applications/host are up to date (e.g., security updates).

The aspects of this activity are presented in Appendix B.2.1.

5.3.2 Maintain the Content of the Project's Website

Maintenance captures updates to the website content and management of the access rights. Some of the foreseen changes or updates include:

- News-items about follow-up activities such as:
  - participation in fairs and conference,
  - creation of spin-offs (who can potentially share the site),
  - tool adoptions,
  - success stories, and
  - framework/repository news.
- Results achieved or approved after the end of the project.
- Information on offered services.

The aspects of this activity are presented in Appendix B.2.2.

5.4 Web-based Repository

The web-based repository is one of the KERs of VALU3S. It is a repository developed in Plone CMS that structures a searchable catalogue of V&V methods and tools applicable to specific domains and scenarios in a multi-layered framework. This repository is currently available at https://repo.valu3s.eu/.

The repository should have updated references to entries on the project's website, currently accessible at https://valu3s.eu (see Section 5.3). The repository also hosts the V&V workflows (discussed in Section 5.5) as well as the project vocabulary discussed in Section 5.6.

The overall aspects of this target are presented in Appendix B.3.

5.4.1 Web-based Repository Infrastructure

The web-based repository *infrastructure* is the web environment that organises, stores, preserves and disseminates the V&V methods and tools framework resulting from VALU3S. The repository infrastructure comprises the following activities:

- Addition of new features.
- Operation of the repository.
- Testing of the repository.

These activities are described in more detail below.

The overall aspects of this target are presented in Appendix B.3.1.

New Features

The *new features* reflect efforts to improve the services and capabilities of the current repository. Some of the new features foreseen are new advanced search, increased scalability and support, complementary plug-ins to extend the functionalities of the framework, or advanced analytics that provide greater insight into the most searched and used V&V methods and tools.

Operate the Web-based Repository

Operation captures the efforts to keep the repository operational and accessible. This includes, for instance, the payment of the domain name and security certificates, technical updates to Plone CMS or periodic security and operability tests.

Testing

Testing captures unit, component, integration, application programming interface (API) and functional tests that should be performed to ensure aspects such as functionality, operability, and security of the repository.

5.4.2 Maintain the Content of the Web-based Repository

Maintenance captures updates and management of the repository content. Currently, each partner has its own account to access the repository and add, modify, or update its content. In the future, it is planned to create review and maintenance accounts that could serve to manage this content. Some of the foreseen maintenance includes:

- Approving updates around V&V methods and tools after project completion.
- Adding and updating information on offered services.

Note that the procedure for any of the above updates should be discussed and agreed upon by the team maintaining the repository.

The overall aspects of this target are presented in Appendix B.3.2.

5.5 Verification and Validation Modelling Language

The VALU3S consortium developed a new graphical DSL, named VVML. This language has been defined as a Unified Modelling Language (UML) profile and supported by tools developed in the Sparx Systems Enterprise Architect (EA) environment.

UML profiles allow the restriction of the many modelling elements supported by the UML language. This has the advantage of identifying a smaller subset of UML capable of representing more focused and precise diagrams. In our case, VVML focuses on workflows of V&V methods, identifying valid sequences of activities; artefacts that are consumed, produced, and shared; and the level of automation of each activity.

Full details over VVML can be found in the public deliverable *"VVML Handbook"* [262]. Examples of workflows described in VVML have been used in other deliverables, including D3.6 [263] on V&V methods and D4.8 [264] on V&V tools. This section focuses on VVML (Subsection 5.5.1) and a repository of VVML workflows (Subsection 5.4.2), intended to show-case how VVML can be used.

Note that the number of elements in the VVML language is not expected to grow, since its attractiveness lies on its conciseness and precision, balancing between expressive power to describe useful V&V workflows and the simplicity to be easy to use and understand. However, the VVML language and its tools may evolve to cope both with new needs, resulting from an increased adoption of VVML, and with the evolution of tool environments.

The overall aspects of this target are presented in Appendix B.4.

5.5.1 Workflow Modelling Tooling

LLSG, in collaboration with other partners of VALU3S, provided tool support for VVML by developing both an *UML profile* for it, and a plug-in for Sparx Systems EA.

UML profiles are used to extend the capabilities of the UML and create DSLs tailored to the needs of a particular domain or industry. *UML profiles* enable to define new stereotypes, tagged values, and constraints for use with existing UML elements such as classes, interfaces, and attributes. This can be used to create DSLs, such as a "*Patient*" class in the healthcare domain or a "*Book*" class in the library management domain.

Using *UML profiles* to create DSLs, such as VVML, has several advantages, including:

- **Increased readability and understandability.** DSLs are created to be simple for domain experts to read and comprehend, enhancing interaction and collaboration between software engineers and domain experts.
- **Enhanced productivity.** DSLs can offer a higher level of abstraction, making it simpler for software engineers to implement and for domain experts to describe their requirements.
- **Reusability.** By using UML profiles in numerous projects, it is not necessary to develop unique languages for each one.

- **Better validation.** UML offers a set of clearly defined semantics for the various diagrams and language components that may be used to validate and confirm the DSL's consistency.
- **Tool support.** UML is a widely used standard and there are a variety of tools available to support the creation, editing, and validation of UML profiles.

Sparx Systems EA is a UML modelling tool for creating and managing UML profiles. It includes a robust set of features for creating custom UML profiles, such as the ability to define new stereotypes, tagged values, and constraints. It also includes a profile editor and a UML profile diagram to assist you in defining and visualising your profiles. Furthermore, EA can import existing UML profiles and use them in modelling projects, allowing to leverage existing profiles created by other organisations or communities.

EA supports the creation, management, and use of UML profiles, which can be very useful when developing DSLs. VALU3S produced both a (free) general UML profile for VVML, and a (proprietary) dedicated plug-in for EA.

The aspects of this activity are presented in Appendix B.4.1.

5.5.2 Model Governance of a Repository of Workflows

Lieber.Group, the holding of LLSG, is currently hosting a collection of VVML workflows developed during the execution of VALU3S. This is an *Enterprise Architect Repository* (EA Repo) different from the web-based repository, described in Section 5.4. The web-based repository shows pictures of the workflows and includes a snapshot of the EA source files of some of these workflows, while the EA Repo holds the editable and current VVML diagrams plus all elements such as artifacts and activities.

The motivation for maintaining the EA Repo is both to document and guide the usage of VVML within EA environment, and to give higher visibility to the methods and tools produced within the VALU3S project. The workflows in the EA Repo will be publicly available to download at LLSG's website (https://www.lieberlieber.com/), including the necessary documentation over these workflows.

We plan to shift the hosting of the EA Repo, and extend it as needed, to a set of public repositories. We are considering three main alternatives (described below). We envision three non-exclusive alternatives to maintain a repository of VVML workflows (in XML format ready to be imported by EA), although others may exist:

- **LLSG owned.** Anybody may download EA Repo (with workflows) and view or edit with locally installed EA.
- **Publicly available.** Read-only access for everybody can be made available via HTML reports, no EA needed in this case.
- **Open to contributions.** Publicly available at a third-party host, such as GitHub or Zenodo, whereas Lieber.Group will act as the *Maintainer* who controls the access permissions. Contributors do not need to be part of Lieber.Group. Typical software-engineering practices, such as fork-and-merge of git repositories, could be used here.

In any of the alternatives above, the VVML models will be under some version control, using technologies such as git or subversion, and using clients such as LLSG's Lemontree that are optimised to handle models rather than text. In the first and second alternative, LLSG plans to provide an official consolidated version every six months.

The aspects of this activity are presented in Appendix B.4.2.

5.6 Vocabulary

The vocabulary supports disseminated results by providing unambiguous meaning of used terms. It collects terms explicitly used in the project context and unifies or narrows down their definitions. The terms in the vocabulary were added upon requests from the review process of the project's reports. The definitions of the terms were built based on the discussions with the project's experts, taking into account definitions in standards and scientific literature, and properly reviewed by technical committee members. The vocabulary is currently published in two forms: (1) a PDF document which follows the guidelines for the project's reports, and (2) a webpage in the project's web-based repository (see Section 5.4) which follows the repository guidelines. The PDF is accessible from the project's website.

The overall aspects of this target are presented in Appendix B.5.

Chapter 6 Conclusions

This chapter draws conclusions and outlines the future perspectives after the completion of VALU3S.

This deliverable is the update of deliverable D6.16 [1], and describes the activities carried out around exploitation and the market analysis within the VALU3S framework and proposes guidelines to maintain the exploitation and visibility of certain results over time.

Unlike deliverables D6.8 [265] and D6.16 [1], where several partners had not yet started to perform activities related to exploitation, during this last year, the percentage of participation in this task has been almost unanimous. This is reflected in the participation rates of the exploitation activities and in the increase of the KPIs' values. Although these indicators were expected to be reached between one and five years after the end of the project, looking at the target values of the seven KPIs that were set in deliverable D6.8 [265] during the first year of the project, after three years, four out of the seven KPIs have already been achieved. It is also worth noting that some of the KPIs that have not yet been achieved have registered a remarkable increase compared to their values in D6.16 [1]. This is the case, for instance, of *Exp-KPI-3. (Potential) agreements with early customers and stakeholders*, which has increased its value from 3 potential agreements last year to 15 this year. Nevertheless, this indicator, as *Exp-KPI-1. Patents registered*, *Exp-KPI-2. Beta testing agreements*, and *Exp-KPI-6. Spin-offs created*, are still far from reaching their target values. However, it is also important to highlight that, to achieve them, it is desirable that the maturity level of the results should be close to the level of the product expected to be commercialised in the future. Currently, most of the project's outcomes are around TRLs 4 and 5, so it is expected that with further development, these KPIs could be achieved in the future.

On the other hand, the market analysis in this document should be considered preliminary. The situation in the six domains analysed is conditioned by the still ongoing effects of the coronavirus [2], the war between Ukraine and Russia [3], and the recent earthquakes in Turkey and Syria earlier this year [4]. Therefore, in order to overcome possible erroneous market forecasts, the main current external risks that could alter market trends and partners' business models are identified, and mitigation measures are proposed to inspire partners in case they have to deal with these hazards.

Lastly, the consortium hopes that its results are not overlooked. Therefore, a designated group has worked on proposing several directions to maintain the sustainability of VALU3S results over time. These actions are not only aimed at maintaining the visibility of the outputs, but also at fostering new partnerships, benchmarking, and creating new business models.

Thus, the consortium expects that the exploitation will not only be limited to the project time of VALU3S. Indeed, with the further enhancement of the developments started during the project, the future achievement of the exploitation KPIs and inspired by the ideas proposed under the motto 'Life-After-VALU3S', it is expected that the results will achieve marketability and attract new stakeholders in the future.

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Appendix A Partners' Specific Market Analysis and Key Exploitable Results

This Appendix contains the specific market analysis and the KERs identified by each of the partners that make up the VALU3S consortium. It is an updated version of the information gathered in deliverable D6.16 [1].

A.1 Use Case Providers

A.1.1 Automotive Domain

Camea Spol. S.R.O.

Organisation short name	CAMEA
Organisation type	SME
Business model	B2C
Key exploitable results	Unicam, a traffic monitoring system based on camera and radar with improved robustness thanks to VALU3S project workflow.

Results to be obtained from VALU3S. Results of the project will be used on CAMEA's most advanced and complex product Unicam. It is a state-of-the-art and field-proven platform for creation of multifunctional and scalable intelligent vision-based and signal processing solutions. The platform has been used in two key areas – intelligent transportation systems and industrial inspection systems. Thanks to various validation/verification techniques and simulation employed to the development process the developed system will be more robust with less human effort spent at the same time.

Identification of market share. Typical target markets in case of traffic monitoring systems are Czech Republic, other European countries (including Russia) and rest of the world as well (Brazil, Kenya…). In case of industrial quality control, the target market is mainly Czech Republic and Europe.

Key market drivers. The economic situation in Europe and the world as municipalities and even manufacturers and usually spend money on or invest to such infrastructure during time of prosperity. In case of traffic enforcement systems, the barriers are various local laws.

Market trends. The need for a traffic surveillance system is becoming increasingly apparent. Moreover, the European car market is one of the most important in the world, and despite the drop in CAGR during the pandemic period, it is expected to recover at a high and steady pace.

Users' profiles. Typical customers in case of traffic monitoring systems are mostly municipalities. In case of industrial quality control, these are typically various manufacturers requesting system suited to their demands.

Competitors. There are some local competitors offering similar systems but none of them offers such complex and extensible family of products. As well on demand adjustments can be done for individual systems/installations.

Stakeholders. Municipalities and industrial and automotive manufacturers.

Roboauto S.R.O.

Organisation short name	ROBO
Organisation type	SME
Business model	B2C
Key exploitable results	ROBO's key exploitable result is to introduce V&V workflow into the development process and thus to increase the quality, safety, and cybersecurity of the released product.

Results to be obtained from VALU3S. ROBO expects to have implemented V&V workflow covering car teleoperation development process with the focus on the use case evaluation scenarios from automotive domain. ROBO's main objective is to make sure from the perspective of both of safety and cyber security that a teleoperated vehicle does not cause material damage or injuries. The VALU3S V&V methods will be used to accomplish that.

Identification of market share. ROBO is in the start-up phase, quite new on the market in the automotive domain. The goal is to increase the market share by being able to provide the end customers with a safe, and secure product.

Key market drivers. With increasing demand in teleoperation area there is also increasing demand on the safety and cybersecurity. ROBO sees an opportunity to start at least basic assessment in ISO 26262 and in preparation for cybersecurity standardization.

Market trends. Offerings in safe AI will increase, giving ROBO a better portfolio of services for its customers. Offerings in cyber security will be a must in a near future, giving it a possibility to offer new services to its customers.

Users' profiles. ROBO's customer profile demands high quality solutions. The challenge will be fulfilling these demands on all the variations of its product in different environments (road, off-road, under water etc.).

Competitors. ROBO's competitors can compete with ROBO by having a stable position on the market, and with the ability to offer the customer more robust system.

Stakeholders. The primary stakeholders are ROBO's own development department – not only teleoperation, but also automotive area. The secondary stakeholders are ROBO's business partners and product end users. The primary stakeholders want to release a product with a good quality. The secondary stakeholders want to use safe and secure product.

NXP Semiconductors

Organisation short name	NXP
Organisation type	Large company
Business model	B2B
Key exploitable results	The obtained results will be transferred into tools and demonstrators to achieve time and cost savings in the verification and validation process for automated systems. In the long term, the results from VALU3S will be taken into account in future semiconductor development work and provide important impulses for future concepts. This is absolutely necessary in order to carry out time-efficient verification and validation in the face of rapidly increasing system complexity and the high demands on safety, security and privacy, and ultimately to make better radar products available to the market faster and more cost-effectively. In an environment characterized by rapid development and high requirements, this is necessary to maintain and expand the leading market position in the field of radar for automotive applications. This is to be made possible by the cooperation in the VALU3S network.

Results to be obtained from VALU3S. NXP will use the results from the VALU3S project in the development process of in-vehicle radar systems and ICs, which are essential for driving assistance systems and necessary for autonomous driving in the long term. The methods for verification and validation of the systems and ICs investigated in VALU3S will make it possible to carry out the development process more time- and cost-efficiently.

Identification of market share. As the world leader in automotive semiconductors, NXP offers advanced solutions for vehicle sensor systems and driver assistance systems. NXP brings its knowledge and innovation potential in the domain of automotive radar systems into VALU3S with the aim to extend its thought leader position in the field.

Key market drivers. In the area of driver assistance, radar is the sensor type with the strongest increase both in terms of the number of units produced and in terms of expected sales, with sales measured in terms of the number of units also exceeding the values of the other sensors, especially with regard to camera sensors, which have a comparable value measured in terms of the number of units.

Market trends. Current market analyses see strong and steady growth in both unit sales and revenues for ADAS, and in particular for radar systems and ICs in automobiles. Distance warning systems based on radar are predicted to have the best growth and market size combination.

Users' profiles. Validation of complex automated systems is becoming increasingly difficult and therefore expensive. NXP's project aims to improve the quality and speed up the system complexity of an entire radar sensor system through novel automated validation methods. This step enables lower costs for radar systems, as many customer tasks can also be accelerated in this way.

Competitors. There are other semiconductor companies with focus on automotive applications who compete in the same market (e.g., Infineon, STMicro). The methods investigated by NXP in VALU3S are aimed towards improving internal V&V processes. The improved time- and cost efficiency will help strengthen NXP's overall position in the market.

Stakeholders. Stakeholders are in-house business lines working on validation and verification in the automotive domain.

CARDIOID TECHNOLOGIES LDA

Organisation short name	CARDIOID	
Organisation type	SME	
Business model	B2B	
Key exploitable results	Cybersecure and validated critical system for electrocardiogram (ECG) biometrics and driver monitoring.	
Other domains	Healthcare	

Results to be obtained from VALU3S. CardioWheel is an intelligent system whose nature is to acquire personal and sensitive data from users, through ECG, and transform it for different end uses. Given the importance of the information the company collects and processes, together with V&V methodologies, CARDIOID will enhance internal processes of data acquisition and transmission, while strengthening cybersecurity of the CardioWheel system and protection of acquired data.

Identification of market share. CARDIOID specialises in the acquisition of ECG biometrics, explores multiple industries within the remote cardiac monitoring market, such as automotive, health and wellness. The CardioWheel system was designed for the automotive industry, given its characteristics and applicability to steering wheels, it focuses not only on the domestic but also the international market.

Key market drivers. Although technological innovation has revolutionised what we knew as the automotive industry, new fundamental values have arisen such as the importance of comfort, new ways of enhancing the safety of vehicle occupants, road users and the vehicle itself. These unmet needs well reflect the potential of a system like CardioWheel, that allows not only the monitoring of the driver's psychophysiological status, *e.g.,* identification of fatigue indicators, ensuring greater road safety, but also improves vehicle safety issues, with the ability to identify and authenticate the user through the ECG.

Human Factors engineering is one of the reasons why CardioWheel meets demand requirements, everything revolves around the individual, the concern for their well-being, safety, and a product capable of delivering new forms of customisation within the vehicle.

Market trends. The Remote Cardiac Monitoring Market is projected to reach USD 31.67 billion by 2028 from USD 4.97 billion in 2021; it is estimated to grow at a CAGR of 30.3% from 2021 to 2028. It is a market with enormous potential, and growth prospects within a short period of time, demand has increased since the outbreak of coronavirus in 2020, with the need for remote monitoring on cardiac patients, releasing pressure off hospitals.

Users' profiles. The CardioWheel system will target those who intend to ensure the safety of the driver and other road users, measure driver's performance and enhance the success of operations with employee safety, reduce road accidents and vehicle down-time, and lower operational costs.

Competitors. Competition landscape includes big medical devices manufacturers, responsible for many implantable remote cardiac devices on the market. Also, new start-ups that have introduced non-medical devices that can be used for cardiac monitoring.

CARDIOID stands out from other companies, as it does not require any action from the user to acquire ECG, it is invisible, automatic, and continuous, presenting itself as a novel preventive monitoring approach.

Stakeholders. CARDIOID's primary stakeholders include leather and electronic components providers, automotive OEMS and vehicle bodybuilders, insurance companies, professional private and public transport sector, consultancy, and service providers of multiple transport modes.

Regarding the secondary stakeholders, it includes local authorities and road safety research institutions.

A.1.2 Agriculture Domain

E.S.T.E. SRL

Organisation short name	ESTE	
Organisation type	SME	
Business model	B2B	
Key exploitable results	V&V testbed for autonomous and semi-autonomous vehicles. ESTE uses the autonomous guidance system developed during VALU3S project to define a new type of product to be proposed to customers or potential customers. ESTE is already collaborating with an industrial domain company to apply the autonomous guidance to a forklift integrating the LIDAR system with GPS and AHRS to use the forklift outside.	

Results to be obtained from VALU3S. The competence and experience acquired with VALU3S and the procedures and framework for V&V of systems, designed in VALU3S, will constitute the core for new services or improved services to be promoted to customers and to acquire new customers in the field of agricultural machines, agricultural robots, and heavy-duty vehicles. ESTE will develop a plan to promote and to make customers aware of the new possibilities in terms of V&V of complex systems in the field of autonomous or semi-autonomous vehicles.

Identification of market share. Currently ESTE focus on the agricultural, earth moving machinery construction market. Exploiting the VALU3S project, ESTE will develop a more all-round approach, in order to extend its visibility and methodology know-how also to pure automotive and industrial compartments.

Key market drivers. The number of new players offering digital solutions to the agricultural sector is growing. However, this offer may be marred by market reluctance due to the lower capacity and limited resources of SMEs to stand out in the international market and the potential high cost of the robotic solution.

Market trends. There is a growing trend towards automation in agriculture.

Users' profiles. Target users range from OEMs to Tier1s or Tier2s.

Competitors. ESTE competes with big consulting companies such as Altran, Teoresi and such. VALU3S may mean a different approach with respect to the competitors both in terms of integration with other project partners and in terms of value of the framework the project has developed.

Stakeholders. Mainly OEMs from the agricultural domain.

A.1.3 Railway Domain

Alstom (Bombardier Transportation Sweden AB)

Organisation short name	ALSTOM (BT)
Organisation type	Large company
Business model	B2C
Key exploitable results	Physical hardware demonstrator.

Results to be obtained from VALU3S. As the provider of the Safe function out-of-context use case, ALSTOM (BT) has obtained a physical hardware demonstrator for its intended safety function where to test all the relevant techniques according to the defined requirements and test procedures in the V&V framework.

Identification of market share. ALSTOM (BT)'s market share is automatic train control.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. These results are not intended for a specific target user.

Competitors. Among ALSTOM (BT)'s competitors is SIEMENS. ALSTOM (BT) is committed to differentiate itself from this competitor by offering additional services in its products that VALU3S project has allowed it to acquire, such as V&V methodologies related to safety in signalling equipment.

Stakeholders. Suppliers and partnerships.

CAF Signalling S.L.

Organisation short name	CAFS	
Organisation type	Large company	
Business model	B2C	
Key exploitable results	A CV&AI enhanced automatic railway signal detector verified and validated using a revolutionary method.	

Results to be obtained from VALU3S. A CV&AI enhanced automatic railway signal detector validated and verified using a revolutionary method. This method is based on virtually generated (using simulators) scenarios to test the object detection algorithm and to test also its robustness facing reduced visibility conditions. The algorithms and AI models will be tested over same railway journey but under different meteorological, daylight or partial occlusion conditions.

Identification of market share. European standardization group of Shift2Rail WP4, in which CAF Signalling is involved, are currently working in a future GoA4 (driverless) ATO system definition. This solution is highly demanded for European railway sector users. CAF Signalling, as same as its competitors (rolling stock and railway signalling suppliers) and newly created technological start-ups, already have started exploring (developing and testing) AI-enhanced computer vision technologies for fully autonomous train operation (visual odometry, automatic object and traffic signal detection and identification, rolling stock automatic coupling…) in order to offer to its clients the benefits of operation cost reduction, railway products life-cycles enlargement and safety increase.

It is hard to establish a market share in such new market opportunity. Deeper exploitation plans and continuous market analysis are required for this purpose.

Key market drivers. The increasing scale of data, computational power and the associated algorithmic innovations are the main drivers for AI-enhanced application progress. These developments also have a huge potential for the railway industry for the future autonomous train perception modules and therefore the interest in deep learning-based technology is growing. Automotive is a good example of it. A lot of the product innovations, such as self-driving cars, parking and lane-change assist or safety functions, such as autonomous emergency braking, are powered by AI based algorithms. Automatic environment perception, obstacle detection, signal identification or shunting operations in depot are expected to get the most attention.

However, The AI-enhanced algorithms for (driverless) autonomous train will need a further substantial effort to increase the TRL before bringing it to the market. AI-enhanced technology must comply with strict standards and safety regulation in order to be certified. AI-enhanced techniques are not currently recommended, so the adoption of such a solution for this domain is still a challenge. For this reason, the main barrier for exploitation will be increasing the TRL for system certification carrying out all safety requirements.

Market trends. There is not any specific offer or pricing policy defined yet in this phase of exploitation plan's definition process.

Users' profiles. European standardisation group is currently working in a future GoA4 ATO (driverless and unattended autonomous train) system definition. This solution is highly demanded for European railway sector users/operators. However, one of the key parts before removing the driver or assistant from the trains is that the train should be able to recognise its environment and detect different dynamic or hazard situation that only a human can do. AI-enhanced applications for automatic environment perception are a mandatory block in any autonomous vehicle, and the railway operators already know it.

Railway sector is very conservative related to safety, for this reason the main challenges the users identified is that this AI-enhanced algorithm should be validated and verified with a new set of method in order to guarantee its robustness.

Competitors. The world rolling stock industry market has traditionally been dominated by two major players, Alstom (France, including now Bombardier) and Siemens (Germany). However, the Chinese rolling stock manufactures have grown substantially and are now ranked third and fourth in the world in terms of turnover. The world market for signalling is rather fragmented and served by various companies. Large companies that act on the signalling market include CAF, Alstom, Ansaldo, Bombardier, Invensys, Siemens, Thales, and Toshiba. AI-enhanced systems for (driverless) autonomous train operation is a quite new market segment. However, there are several approaches which can be marketed in next years.

On the other hand, several SME and start-ups (Railvision, OTIV, Cognitive Pilot, HORUS, ROBO…) are offering an AI-enhanced solution for autonomous train operations. Although their maturity level are still very low, these organisations might be key agents (competitors or partner) in this market segment.

Stakeholders. 1) Users/Operator: They need to increase (in a safe way) the railroad occupancy (revenue) and make their train operations more efficient (cost) improving the punctuality and energy saving issues and keeping passenger comfort.

2) Suppliers: They need to incorporate the new AI technologies and the applications of SoA to their portfolio.

3) Providers: Usually newly created start-ups which can speed up the supplier's developments becoming partner with them.

4) Regulation agencies: They should define new ways to certificate AI-based applications which are not any more deterministic but probabilistic. This paradigm change needs new ways to deal with these applications safety requirements.

A.1.4 Healthcare Domain

RGB Medical Devices S.A.

Organisation short name	RGB	
Organisation type	SME	
Business model	B2B	
Key exploitable results	The key exploitable result will be an infusion controller for NMT regulation. This will be sold as an SW component to be incorporated in existing multi-parameter monitors that have NMT monitoring capabilities.	

Results to be obtained from VALU3S. Exploitable results are not expected within the limited time frame of VALU3S project. The main difficulty is that the product, an infusion controller for neuromuscular transmission (NMT) regulation, is a type III life dependent device, and will require very strict technical and clinical tests for compliance with regulatory issues. This is something that will take longer and does not even depend on RGB´s will.

Identification of market share. If such a product will be at some point commercially available, it would be a unique solution in the market.

Key market drivers. Product compliance with current norms in each country requires going step by step, country by country; this is however common in the medical field, but it is highly time consuming.

Market trends. The RGB´s expectation is that after VALU3S time frame, RGB will be able to offer a specific SW component integrated in a multi-parameter monitor, which will enhance the current capabilities and incorporate the closed-loop capabilities of the infusion controller.

Users' profiles. The product is targeted towards patients in operating room or intensive care units. In general, for critical care units.

Competitors. There will be competitors, mainly from big companies, as the product is in line with the emerging robotic care in critical care.

Stakeholders. As usual, the prescriptors of the product are the anesthesiologists and intensivists, but the purchase decision is taken by the hospital management. The product exploitation will benefit from current commercial network of RGB.

CARDIOID TECHNOLOGIES LDA

Organisation short name	CARDIOID
Organisation type	SME
Business model	B2B
Key exploitable results	Cybersecure and validated critical system for electrocardiogram (ECG) biometrics and driver monitoring.
Other domains	Automotive

Results to be obtained from VALU3S. CardioWheel is an intelligent system whose nature is to acquire personal and sensitive data from users, through ECG, and transform it for different end uses. Given the importance of the information the company collects and processes, together with V&V methodologies, CARDIOID will enhance internal processes of data acquisition and transmission, while strengthening cybersecurity of the CardioWheel system and protection of acquired data.

Identification of market share. CARDIOID specialises in the acquisition of ECG biometrics, explores multiple industries within the remote cardiac monitoring market, such as automotive, health and wellness. The CardioWheel system was designed for the automotive industry, given its characteristics and applicability to steering wheels, it focuses not only on the domestic but also the international market.

Key market drivers. Although technological innovation has revolutionised what we knew as the automotive industry, new fundamental values have arisen such as the importance of comfort, new ways of enhancing the safety of vehicle occupants, road users and the vehicle itself. These unmet needs well reflect the potential of a system like CardioWheel, that allows not only the monitoring of the driver's psychophysiological status, *e.g.,* identification of fatigue indicators, ensuring greater road safety, but also improves vehicle safety issues, with the ability to identify and authenticate the user through the ECG.

Human Factors engineering is one of the reasons why CardioWheel meets demand requirements, everything revolves around the individual, the concern for their well-being, safety, and a product capable of delivering new forms of customisation within the vehicle.

Market trends. The Remote Cardiac Monitoring Market is projected to reach USD 31.67 billion by 2028 from USD 4.97 billion in 2021; it is estimated to grow at a CAGR of 30.3% from 2021 to 2028. It is a market with enormous potential, and growth prospects within a short period of time, demand has increased since the outbreak of coronavirus in 2020, with the need for remote monitoring on cardiac patients, releasing pressure off hospitals.

Users' profiles. The CardioWheel system will target those who intend to ensure the safety of the driver and other road users, measure driver's performance and enhance the success of operations with employee safety, reduce road accidents and vehicle down-time, and lower operational costs.

Competitors. Competition landscape includes big medical devices manufacturers, responsible for many implantable remote cardiac devices on the market. Also, new startups that have introduced non-medical devices that can be used for cardiac monitoring.

CARDIOID stands out from other companies, as it does not require any action from the user to acquire ECG, it is invisible, automatic, and continuous, presenting itself as a novel preventive monitoring approach.

Stakeholders. CARDIOID's primary stakeholders include leather and electronic components providers, automotive OEMS and vehicle bodybuilders, insurance companies, professional private and public transport sector, consultancy, and service providers of multiple transport modes.

Regarding the secondary stakeholders, it includes local authorities and road safety research institutions.

A.1.5 Aerospace Domain

United Technologies Research Centre Ireland

Organisation short name	UTRCI
Organisation type	RTO
Business model	B2B
Key exploitable results	Innovative simulation-based verification framework to provide advanced control V&V of aircraft engines. This will have a big impact in the engine controller design cycle as it accelerates the process while providing results that could be used for certification purposes.

Results to be obtained from VALU3S. The main, overall exploitation of VALU3S technology will be used in UTRC to validate and verify advanced control engine concepts currently developed in its business units. To that end, UTRC aims to exploit scalable and accurate verification frameworks from VALU3S to prove engine control safety, performance, and robustness under certain environmental faults. Results will be used to provide additional evidence and certification credits in order to accelerate development, verification and production of new engine control products.

Identification of market share. The relevant markets and customers include all aircraft manufacturers that seek certification evidence for engines' efficient operation and control under aerospace regulations.

Key market drivers. The main opportunities will be originated from the application of new V&V methods that exhibit successful results over high-complexity engine control models. The main barriers identified are the scalability of the applied V&V methods as well as the requested automation with respect to verification engineer involvement to obtain final results.

Market trends. As the engine requirements tend to include safety, performance (e.g., fuel consumption) and reliability (operation under certain faults), being able to verify and demonstrate early in the design cycle that the engine control approach meet its criteria will open a new business model for new faster engine customizations per customer requests.

Users' profiles. Main customers will be aircraft manufacturers (Airbus, Boeing) that seek to integrate engine models to their aircraft governor-model at a system engineering point of view. Verification results will confirm engine control characteristics to be validated and certified when delivering the end product.

Competitors. Engine manufacturers and FADEC developers (RR, Safran, GE) that provide efficient and safe engines and engine control solutions based on customer preferences.

Stakeholders. System engineers, verification engineers, certification authorities.

A.1.6 Industrial Robotics/Automation Domain

Siemens AG Österreich

Organisation short name	SIEMENS	SIEMENS
Organisation type	Large company	
Business model	B2B	
Key exploitable results	The application of an easy-to-use digital twin integration verification concept for open-source CPUs in the use case demonstrator eases open-source processor integration verification of motion control systems and thus reduce costs for verification and validation efforts.	

Results to be obtained from VALU3S. The VALU3S V&V framework and an integration verification concept eases the replacement of a legacy core in a digital twin and thus reduces costs of verification and validation efforts. A successful replacement of commercial processors with open-source processors in the use case, that only introduces minimal and acceptable functional deviations to the design, marks an important step towards approaching a wider integration of open-source CPUs in business products.

Identification of market share. The primary target market for the exploitable results is Motion Control. However, other markets such as Energy Automation and Medical Devices can be targeted.

Key market drivers. The exploitable results of VALU3S are expected to reduce V&V efforts as well as savings in licensing costs for processor cores, resulting in an overall cost reduction. Open-source designs might also reduce resource consumption such as die area and power. These reasons are an advantage which competitors' products might not have, yet.

Market trends. SIEMENS focuses on highly reliable, high performance and scalable motion control products for industry. Cost-efficiency for customers with open-source CPUs can be a distinctive advantage to competitors' products.

Users' profiles. On the long run there can be potential customers for open-source CPUs within the Railways Sector, which also has high demands on safety. Especially here a reliable supply chain and long-term availability guarantees are key requirements for open-source solutions.

Competitors. Alstom, Philips, Bombardier, CAF, Beckhoff, GE, Hitachi, Knorr Bremse, ABB, Thales, Schneider Electric, Emerson, Mitsubishi Electric, Toshiba, Honeywell International, Bosch, and many more.

Stakeholders. Primary Stakeholders for Siemens Technology are in-house divisions / business units designing and producing Motion Control Systems, Energy Automation Products, Medical Devices and Railway Applications. Secondary Stakeholders are Siemens' customers from above sectors worldwide.

Pumacy Technologies AG

Organisation short name	PUMACY
Organisation type	SME
Business model	B2B
Key exploitable results	-

Results to be obtained from VALU3S. As provider of Use Case 4 "Human-Robot-Interaction in Semi-Automatic Assembly Processes", PUMACY targets to develop and exploit an activity and process mining stack for the purpose of human activity recognition and process optimization. Further developments are likely required in order to create commercial products and services, to connecting to the VALU3S multidimensional layered framework.

Identification of market share. PUMACY's market share will be major suppliers in the consumer goods, automotive and electronics industry.

Key market drivers. Collaborative robotics is currently being employed by a large number of companies as a tool to support assembly activities within their production line. However, this technology requires improvements in safety to exploit its full potential.

Market trends. The reduction in the price of robotics will allow more and more companies to opt for its use.

Users' profiles. PUMACY will address SME and large-scale manufacturing companies within its existing customer portfolio but also from identified potential customers in previously mentioned market share. In addition, it targets manufacturers who outsource their V&V processes for cyber-physical systems in HRI based on production and product assembly.

Competitors. Activity/pattern recognition and process mining in the domain of robotics and especially HRI is a relatively new field of application. Though, there are machine and robot manufacturers, such as ABB, KUKA, Fanuc, Thyssen-Krupp System Engineering, or Siemens, who still have to overcome the challenge of heterogeneous landscapes with combined machines of different vendors.

Stakeholders. Manufacturers (SME and large-scale manufacturing companies) with product assembly lines.

Otokar AS

Organisation short name	OTOKAR	
Organisation type	Large company	
Business model	Commercial Foundation	
Key exploitable results	1) Novel hardware and software to be brought to the sector. 2) Exploited results will provide further benefit on safety and security. 3) A system to increase quality, which takes less time to make inspection, with less cost.	

Results to be obtained from VALU3S. OTOKAR is aiming to provide a better fault-tolerant production system to achieve better quality control for automotive body-in-white. Controlling the existence of 2500-3000 body parts is planned to be executed fully automatically by Cartesian robot and camera sensor system. Connected inspection system will be safe and secure.

Identification of market share. The system will be competitive in quality inspection solutions of large vehicles. These kinds of solutions contain robotics, automation, and camera sensor components.

Key market drivers. Turkey is already a production base for large vehicles. Turkey is also close to other large vehicle production bases. Moreover, the existing solutions are not feasible in terms of price and cycle time.

Market trends. Simulation supported safe trajectory creation and secure design properties of the system will make OTOKAR's solution faster than the others, which mean that it can be used where higher production capacities are needed. In addition to this, automatic trajectory creation will cancel the manual trajectory teaching and it will reduce the time to market of new vehicles. Moreover, low labour costs in Turkey will make the solution cost competitive.

Users' profiles. As these systems are expensive, it is important ensure the safety of the robot. Therefore, to teach or provide a trajectory, an experienced user is needed. OTOKAR's solution eliminates the need for manual trajectory teaching and the need for an experienced user. Moreover, in IoT concepts it is needed to reach the system from a distant server. OTOKAR's solution's cybersecurity hardware and software enables to do so.

Competitors. OTOKAR's system uses an inspection method different from the ones used in the market and this makes the system first in the world. It can create inspection trajectory, which is safe, automatically. This is also a property, which the products in the market do not have.

Stakeholders. N/A.

Electrotécnica Alavesa S.L.

Organisation short name	ALDAKIN	
Organisation type	SME	
Business model	B2C	
Key exploitable results	Human-robot interaction robotic cell for disassembly.	

Results to be obtained from VALU3S. ALDAKIN will obtain a reinforcement learning-controlled human-robot interaction cell that will be able to interact with personnel with disabilities. This solution, together with the V&V methodologies that will be worked on by means of advances simulation tools, will allow ALDAKIN to acquire a high value-added product and know-how that can be applied in the coverage of current tests and in the reduction of related efforts especially for safety and performance in collaborative robotics.

Identification of market share. ALDAKIN is an SME specialising in the development of electrical engineering, automation, and collaborative robotics solutions, including industrial automation, robotics, industrial computing, electronics and automatic instrumentation and regulation. In robotics, due to its capabilities and scope, the company mainly focuses on the domestic market.

Key market drivers. With Industry 4.0, robotics has been one of the fastest growing sectors in recent years. However, many handling tasks cannot be fully automated, so it is necessary that the human factor is present in the production chain. In this sense, collaborative robotics has certain advantages over conventional industrial robotics, as it combines the capabilities of the human being with those of the robot. However, there is still reluctance in the market to adopt this type of solution. Since the robot is in direct contact with the worker, the safety of the individual is much more at risk. It is therefore necessary to develop a completely safe cell that promotes agile production while ensuring the well-being of the operator.

Market trends. Despite the coronavirus and recent socio-economic events, the robotics market is expected to grow at a CAGR of around 5.8% over the next years. In this respect, collaborative robotics will receive a major attention. Lower prices in the robotics sector will make collaborative robotics more affordable, allowing even SMEs to include it in their production chain.

Users' profiles. The robotic cell that will be obtained after the completion of the project will be aimed at companies that focus on the disassembly of products at the end of their useful life. Although these companies may have personnel with disabilities on their staff, the robotic solution can be used in any disassembly plant and will be intended to automate tasks that may involve a great deal of effort for the personnel in charge of performing them.

Competitors. Among ALDAKIN's competitors are Iruña Automatización, Inali, Inser and Martec. ALDAKIN is committed to differentiate itself from these competitors by offering additional services in

its products that VALU3S project will allow it to acquire, such as verification and validation methodologies related to safety and performance in robotic cells.

Stakeholders. Primary stakeholders include entities that base their activity on the disassembly of end-of-life devices. Regarding secondary stakeholders and given that the robotic cell can be used with people with disabilities, this includes non-profit organisations whose aim is the social and labour inclusion of people with disabilities.

A.2 SME and Large Organisations (Use Case Contributors)

A.2.1 Automotive Domain

LieberLieber Software GmbH

Organisation short name	LLSG	
Organisation type	SME	
Business model	B2B	
Key exploitable results	-	
Other domains	Railway	Aerospace

Results to be obtained from VALU3S. System engineering is one of LLSG's main areas of competence. It offers 1) profound knowledge of development languages such as UML and SysML, 2) AUTOSAR modelling with Enterprise Architect, 3) implementation of Functional Safety Requirements in accordance with industry standards via Enterprise Architect, UML and more, 4) code generation and traceability, 5) model validation ensures adherence to modelling methodology, 6) Functional Safety Management – Models are ideally suited to comprehensively implement and functional safety requirements and 7) parallel development of versions and variants.

Identification of market share. European model-based systems engineering, mainly focus on Germany, Austria and Switzerland.

Key market drivers. Cloud security, risk management, security by design.

Market trends. N/A.

Users' profiles. Large engineering teams located on multiple destinations.

Competitors. Among LLSG's competitors are Rhapsody (IBM), MagicDraw and Cameo Business Modeler (Dassault Systèmes).

Stakeholders. N/A.

QRTECH AB

Organisation short name	QRTECH	
Organisation type	R&D Services	
Business model	B2B	
Key exploitable results	Increased organizational knowledge in cyber security and improved process for V&V using penetration testing that can be used to elevate current and gain new services for the automotive industry.	

Results to be obtained from VALU3S. QRTECH expects to gain knowledge in the area of V&V within security requirements as well as safety. Specifically, it expects to have a test bench and toolchain that can implement testing of requirements related to cybersecurity for the automotive domain, for example, penetration testing.

Identification of market share. QRTECH currently holds a stable position in the local automotive domain, mainly on the embedded side, continuously working with safety and AI. It aims to keep that market share by also being able to assess cybersecurity in conjunction with safety.

Key market drivers. There is an emerging standard for cybersecurity in the automotive domain; this is an opportunity for QRTECH, since it is currently developing technology for the assessment of cybersecurity.

Market trends. Offerings in cybersecurity will be a must in a near future, giving QRTECH a better portfolio of services for its customers as well as giving a possibility to bundle current services with new technologies.

Users' profiles. As a B2B engineering service company, its customer profile demands high quality solutions, cutting edge technical excellence and facts to support all design decisions.

Competitors. Similar to QRTECH, though it finds an edge in providing knowledge in the latest technologies, this is the driver for participating in VALU3S. Its competitors can compete with lower prices for less complex projects.

Stakeholders. The primary stakeholders are the product and software development teams and managers, as well as integrators and industry customers. Secondary stakeholders could be the end user.

Infotiv AB

Organisation short name	INFOTIV
Organisation type	SME
Business model	B2C
Key exploitable results	Through the project, INFOTIV will gain new knowledge and experience that can elevate the market and open new business opportunities.

Results to be obtained from VALU3S. Knowledge and experience of working with simulators in a V&V process. New and increased knowledge of the value and strength of new methods, and where to use them.

Identification of market share. By participating in VALU3S, INFOTIV will gain experience and knowledge that can be used to gain market shares and a competitive edge.

Key market drivers. When it comes to opportunities INFOTIV sees a huge potential in the work done in VALU3S. Especially, the work around enhancing methods for V&V.

Market trends. For INFOTIV, the knowledge gained from VALU3S will enable the company to help its clients with an extended offering.

Users' profiles. Software companies working with machine learning models and companies in need of training in how to work with quality assurance within the technical domain.

Competitors. In the field of providing consultancy work for V&V of safety functionality based on ML, there is not much of competition among consultancy companies. INFOTIV's strength is its close collaboration with automotive industrial partners with Sweden.

Stakeholders. Industrial product manufacturers, product and software development teams, R&D institutes and researchers, educational partners.

Berge Consulting AB

Organisation short name	BERGE
Organisation type	SME
Business model	B2B
Key exploitable results	New technology and workflows being developed, as well as the simulator itself since it can be adaptable and adjusted to new customers requirements and needs.

Results to be obtained from VALU3S. A scalable simulation environment built in Unreal engine. Ability to simulate effective evaluations of cyber-physical automated systems and sensor utilization.

Identification of market share. Within the automotive sector where companies want to simulate sensors, AI or other traffic related scenarios.

Key market drivers. Physical testing is expensive, ineffective and time consuming. This is a way to get better results quickly with the use of less resources. Security regarding the sensors and result of the simulation is important. The need for authorization from governments will be less since the test will be done in a simulator on a computer.

Market trends. More and more testing in the world is done virtually instead of physical, in everything from fuel consumption to crash tests. There is a huge cost saving potential for companies in going from physical to virtual testing, both in hardware, less test personnel and time spent on setting up the test.

Users' profiles. To be able to test cases that occur very rarely will be invaluable for companies. Instead of waiting for a situation to happen, we can test that in the simulator immediately. To switch from physical testing to virtual will require new competencies and to require new and replace the old competencies will be a challenge.

Competitors. CARLA, LGSVL and NVIDIA DRIVE SIM are the main competitors. NVIDIA is a major company with large resources, CARLA is open-source and LGSVL has a high graphic level.

Stakeholders. Primary stakeholders are companies that make sensors for automotive customers and secondary are the automotive companies them self.

A.2.2 Agriculture Domain

STAM SRL

Organisation short name	STAM
Organisation type	SME
Business model	Provision of tools and consultancies through the usage of the tools (B2B)
Key exploitable results	RAMSES: Risk Analysis web application for the secure design of industrial and agricultural machinery according to ISO 12100.

Results to be obtained from VALU3S. STAM has achieved the development of a Risk Assessment web-based application dedicated to robots and automated systems implied in the agriculture domains, in order to enhance the safety & security of the system and protect the business of system owners. Such Risk Analysis tool, called RAMSES, is useful to automatize the risk analysis process following ISO12100 methodology. This help users in decreasing time and cost needed for the risk assessment during design phase while keeping high safety & security standards compliant with ISO12100.

Identification of market share. It has been estimated that the Agricultural Robot market will grow by 24% during the forecast period from 2023 to 2026. Indeed, this growing trend make reasonable to assume the achievement of a minimum viable market for this kind of application. It is worth to notice that RAMSES is applicable also to other domains (e.g., industry) with minor adjustments.

Key market drivers. One of the main market opportunities will be to take advantage of the growing trend towards automation also in agriculture. Of course, introduction of automated systems can cause both benefits but also threats. Indeed, risk analysis is a fundamental process to mitigate the occurrence of threats and the impact on business, operations, and people. Furthermore, companies designing such automated systems should undertake a risk analysis compliant with ISO12100 standard to adequately evaluate risk and mitigate them through design of safety functions. It is worth to notice that ISO12100 is applicable also to automated systems belonging in other domains (e.g., industry).

Market trends. The number of new players offering digital solutions to the agricultural sector is growing. There are about 740 agrifood Startups at an international level, for a total of 13.5 billion dollars in funding raised. These start-ups are mainly active in the eCommerce (70%) and Agriculture 4.0 sectors (20%). It is worth noticing that RAMSES is applicable also to other domains (e.g., industry) with minor adjustments.

Users' profiles. Designer of automated vehicles and other systems for agricultural applications, safety engineers auditing that design is compliant with ISO12100 standard.

Competitors. Leonardo, Engineering, ALTEN, Accenture, Yarix and those all-large players working in Safety & Security of systems.

Stakeholders. Agri-food companies, system integrators, provider of agri-robots, policymaker in the agriculture domain. It is worth to notice that RAMSES is applicable also to other domains (e.g., industry) with minor adjustments.

Rulex Innovation Labs SRL

Organisation short name	RULEX
Organisation type	SME
Business model	B2C
Key exploitable results	-

Results to be obtained from VALU3S. RULEX aims at developing XAI approaches and workflows to detect and possibly address potentially risky situations from both security and safety point of view. These workflows can be coupled with more traditional approaches to improve security and safety both at a design level (enriching knowledge about the system) and at a runtime level (providing alerts and enabling autonomous actions). This approach is transversal, so RULEX will be able to apply the results acquired in this domain to any other domain worked on in VALU3S.

Identification of market share. RULEX does not aim to directly address final users but is looking for partners (system integrators in the specific domain) able to include AI solutions in their proposal to the final user (i.e., the agriculture robot manufacturer).

Key market drivers. Even if AI has reached maturity, there is always some resistance in its adoption in key processes. This is due to many factors mainly related to the gap between technology and business experts. Moreover, since the approach is based on data, the availability of high-quality data is crucial point to implement this type of solution.

Market trends. N/A.

Users' profiles. RULEX is not aiming to directly address final users.

Competitors. Currently, RULEX is not aware of similar solutions in this domain.

Stakeholders. System integrators of different domains.

Intecs Solutions S.p.A.

Organisation short name	INTECS	
Organisation type	Large company	
Business model	B2C	
Key exploitable results	Model-based safety analysis solution integrated with a modelling environment supporting fault identification and propagation to support hazard analysis, optimization of failure injection during V&V.	
Other domains	Healthcare	

Results to be obtained from VALU3S. Model based safety analysis solution integrated with a modelling environment supporting fault identification and propagation to support hazard analysis, optimization of failure injection during V&V by using results from the analysis, addressing safety aspects and support for certification processes.

Identification of market share. Although INTECS has worked on use case in the agriculture and healthcare domains at VALU3S, the company also targets other domains such as automotive and aerospace.

Key market drivers. One of the main opportunities will be to enable confidence building processes in the agricultural domain, as well as to increase expertise and create new employment opportunities, in the field of certification for the agricultural domain.

Market trends. N/A.

Users' profiles. INTECS has proven experience in V&V and risk assessment, qualitative and quantitative RAMS analyses and methods, working with the most demanding standards in national and international projects in various domains (Aerospace, Automotive, Railway, and Telecommunications).

Competitors. Engineering, ALTEN, Accenture, Yarix and other large system consulting companies are involved in the Safety & Security of systems.

Stakeholders. Large system developers, integrators, and OEM companies.

A.2.3 Railway Domain

LieberLieber Software GmbH

Organisation short name	LLSG	
Organisation type	SME	
Business model	B2B	
Key exploitable results	-	
Other domains	Automotive	Aerospace

Results to be obtained from VALU3S. System engineering is one of LLSG's main areas of competence. It offers 1) profound knowledge of development languages such as UML and SysML, 2) AUTOSAR modelling with Enterprise Architect, 3) implementation of Functional Safety Requirements in accordance with industry standards via Enterprise Architect, UML and more, 4) code generation and traceability, 5) model validation ensures adherence to modelling methodology, 6) Functional Safety Management – Models are ideally suited to comprehensively implement and functional safety requirements and 7) parallel development of versions and variants.

Identification of market share. European model-based systems engineering, mainly focus on Germany, Austria and Switzerland.

Key market drivers. Cloud security, risk management, security by design.

Market trends. N/A.

Users' profiles. Large engineering teams located on multiple destinations.

Competitors. Among LLSG's competitors are Rhapsody (IBM), MagicDraw and Cameo Business Modeler (Dassault Systèmes).

Stakeholders. N/A.

A.2.4 Healthcare Domain

Knowledge Centric Solutions S.L. (The REUSE Company)

Organisation short name	TRC
Organisation type	SME
Business model	B2C
Key exploitable results	V&V-centred systems engineering tool suite.

Results to be obtained from VALU3S. The main, overall exploitation of VALU3S results will be (1) the extension of TRC's tool suite for systems engineering and (2) the extension of the application domains and systems in which TRC tools are used.

The specific exploitable results will be (1) a V&V-centred systems engineering tool suite and (2) an assurance & certification-targeted approach and tool support for automated system V&V that exploits AI, semantic technologies, and model-based techniques.

Identification of market share. The relevant markets and customers include automatic quality assessment and V&V markets for system artefacts such as requirements and models. The planned TRC results are applicable in practically any industrial domains in which critical systems are deployed (aerospace, automotive, railway, healthcare, etc.).

Key market drivers. The main opportunities will come from the development of new, advanced V&V solutions that exploit e.g., AI and semantic technologies. On the other hand, the main barriers could be that (1) the results are not sufficiently aligned with engineering standards and (2) the use in industry of the results depend on base practices that build on knowledge management, which are not widespread techniques yet.

Market trends. As the complexity of safety-critical system development grows, the companies involved in this process require tools that make it cost-effective by providing advanced support. TRC's vision towards systems engineering tools that exploit AI and semantic technologies can greatly help these companies.

Users' profiles. TRC's customers profile is companies manufacturing Cyber-Physical System. The domains of TRC's customers are quite diverse: Aerospace, Automotive, Healthcare, Legal, etc.

The main stakeholders of TRC's products are systems engineers in charge of the design of the system of systems.

The main challenge is to provide a tool that helps customers to go through their V&V processes.

Competitors. Companies offering similar products include QRA Corp (https://qracorp.com/), IBM (https://www.ibm.com/products/requirements-quality-assistant), and Model Engineering Solutions (https://model-engineers.com/en/).

Stakeholders. Automated system manufacturers, automated system component suppliers, certification authorities, system assessors.

Intecs Solutions S.p.A.

Organisation short name	INTECS	
Organisation type	Large company	
Business model	B2C	
Key exploitable results	Model-based safety analysis solution integrated with a modelling environment supporting fault identification and propagation to support hazard analysis, optimization of failure injection during V&V.	
Other domains	Agriculture	

Results to be obtained from VALU3S. Model based safety analysis solution integrated with a modelling environment supporting fault identification and propagation to support hazard analysis, optimization of failure injection during V&V by using results from the analysis, addressing safety aspects and support for certification processes.

Identification of market share. Although INTECS has worked on use case in the agriculture and healthcare domains at VALU3S, the company also targets other domains such as automotive and aerospace.

Key market drivers. One of the main opportunities will be to enable confidence building processes in the healthcare domain, as well as to increase expertise and create new employment opportunities, in the field of certification for the healthcare domain.

Market trends. N/A.

Users' profiles. INTECS has proven experience in V&V and risk assessment, qualitative and quantitative RAMS analyses and methods, working with the most demanding standards in national and international projects in various domains (Aerospace, Automotive, Railway, and Telecommunications).

Competitors. Engineering, ALTEN, Accenture, Yarix and other large system consulting companies are involved in the Safety & Security of systems.

Stakeholders. Large system developers, integrators, and OEM companies.

A.2.5 Aerospace Domain

LieberLieber Software GmbH

Organisation short name	LLSG	
Organisation type	SME	
Business model	B2B	
Key exploitable results	-	
Other domains	Automotive	Railway

Results to be obtained from VALU3S. System engineering is one of LLSG's main areas of competence. It offers 1) profound knowledge of development languages such as UML and SysML, 2) AUTOSAR modelling with Enterprise Architect, 3) implementation of Functional Safety Requirements in accordance with industry standards via Enterprise Architect, UML and more, 4) code generation and traceability, 5) model validation ensures adherence to modelling methodology, 6) Functional Safety Management – Models are ideally suited to comprehensively implement and functional safety requirements and 7) parallel development of versions and variants.

Identification of market share. European model-based systems engineering, mainly focus on Germany, Austria and Switzerland.

Key market drivers. Cloud security, risk management, security by design.

Market trends. N/A.

Users' profiles. Large engineering teams located on multiple destinations.

Competitors. Among LLSG's competitors are Rhapsody (IBM), MagicDraw and Cameo Business Modeler (Dassault Systèmes).

Stakeholders. N/A.

A.2.6 Industrial Robotics/Automation Domain

Inovasyon Muhendislik Ltd. Sti.

Organisation short name	IMTGD
Organisation type	SME
Business model	B2C
Key exploitable results	Novel methods for simulation-based testing that can be used in various domains and will challenge stakeholders to improve new technologies.

Results to be obtained from VALU3S. IMTGD will obtain results from simulation and fault injection technologies. Fault injection mechanisms will be integrated to simulated autonomous robot system. This process will bring a wide range of test capabilities for assessing safety of robots, assets and robot's trajectory.

Identification of market share. Simulation based testing methods are emerging with increasing power of computers. Increasing importance of safety verification in multi-robot, human-robot collaborative systems will increase importance of simulation-based testing methods because of low risk, scalability and price. In coming years of innovation, IMTGD will be part of this emerging market.

Key market drivers. Many industries are increasingly turning to automation to improve efficiency, reduce costs, and increase productivity. This trend is expected to continue in the future, driving the demand for advanced robotics systems. As industries become more dynamic and demand for customisation increases, robotic systems that can adapt to changing environments and tasks will be in high demand.

Market trends. Long term remote working in 2019 pandemic has affected market trends and importance of digital collaboration is increased. In this manner, online testing and digital test infrastructures have started getting into trends.

Users' profiles. With 2021, the user needs will shift towards trust, safety and inclusion. With effect of pandemic, trend is moving towards digitalization in many areas.

Competitors. In this trend of digitalisation of V&V applications, Testing as-a-Service (TaaS) applications compete against IMTGD. However, with scalability and level of simulation, IMTGD will challenge the market.

Stakeholders. Customers are a critical stakeholder group, as they are the ultimate users of the company's products and technologies. The company needs to understand their needs and preferences to develop products that meet their requirements. Suppliers are an important stakeholder group, as they provide the raw materials, components, and equipment needed to develop and manufacture the company's products. Regulatory bodies such as the FDA, FCC, or EPA play an important role in

ensuring that the company's products comply with safety and environmental standards. The company may collaborate with other organisations, such as universities, research institutions, or other companies to develop new technologies, products or expand their market.

ERARGE Ltd. Sti.

Organisation short name	ERARGE	
Organisation type	SME	
Business model	B2C	
Key exploitable results	1) Hardware Security Module, PRIGM, tailored for Industry 4.0 and automotive applications, providing main cryptographic functionalities (symmetric and asymmetric cryptographic functions, hashing, and key management), true random number generator and strong cryptographic key generation, and online/on-device true randomness tests. 2) Secure Gateway, Senstation, tailored for Industry 4.0 and automotive applications which are combined with FIDO-compliant person authentication and node authentication.	

Results to be obtained from VALU3S. ERARGE has benefited from the field studies (UC11) to position its hardware-based V&V methodology within the VALU3S context. The developed methodology has been used in the hardware and middleware implementation of PRIGM and Senstation. The developed tools and devices have been applied to analyse the vulnerabilities originated from threats at low level hardware or system components. The hardware-based countermeasures of ERARGE against cyber threats, like HSM, secure IoT gateway and authentication solutions, are used to protect industrial settings and cyber-physical systems by cryptographic means. The developed tools have been adapted to the needs of the automotive industry which is evident from the field studies conducted with Otokar. It has been seen that the solutions are useful for automotive OEMs to comply with new regulations like UNECE 155/156 and standards related to safety and cybersecurity. It has been proved that the developed solutions can be used both for organisational security and infrastructure security not only in Industry 4.0 but also automotive domain. These developments have turned in to three projects: OPEVA - OPtimization of Electric Vehicle Autonomy (HEU KDT 2022-1-RIA); ii) ESCALATE: Powering European Union Net Zero Future by Escalating Zero Emission HDVs and Logistic Intelligence (with our sister company ERGTECH, HEU- CL5-2022-D5-01-08); iii) YEHO – Innovative Electrical, Connected and Autonomous Vehicle (HAMLE- national project).

Identification of market share. The HSM and hardware security market is growing with the investments of pioneering companies like Thales, IBM, Microsoft, Google, Amazon, Utimaco, etc. However, there is a strong need in the market to specialise the hardware-based solutions with new trends like cloud-based service-oriented architectures (Crypto-as-a-Service), online and on-device V&V and vulnerability check, and high-throughput micro-service operations. ERARGE, has identified this gap in the market and VALU3S results will help ERARGE promote its SCP countermeasure tools (HSM, namely PRIGM©; Secure gateway, namely Senstation©).

Key market drivers. The eIDAS initiative and the current cybersecurity trends mentioned by ENISA, FIDO compliance promoted by big players (e.g., Google) for the node and person authentication, new regulations forcing automotive industry to comply with new regulations (UNECE 155/156) and also the

boom of blockchain-oriented applications (promoted by European Blockchain Services Infrastructure) will create new opportunities for the wider uptake of ERARGE's hardware-based SCP solution stack. The main barrier can be the low level of legislation and standardisation related to the multi-stakeholder and cross-border cooperation among industrial partners in the new decentralised world. The recent earthquakes in Turkey and Syria and the Ukraine-Russia war may influence the investments. However, these disasters and wars may also bring opportunities because the resilience of critical infrastructures like factories need to be improved against cyber threats. This is also valid for the automotive and logistics sectors which are always under the risk to cybercrime.

Market trends. Coronavirus has reshaped the market due to the changing working style from settled and centralised to dynamic and decentralised, requiring more remote working and multi-stakeholder collaboration. Thus, the strategy of presenting V&V-as-a-service for different domains can bring many opportunities. ERARGE has identified this and upgraded its hardware-security devices to crypto-as-a-service, authentication-as-a-service and cyber-resilience-as-a-service to reduce the operational costs and reach at a wider portfolio and number of customers.

Users' profiles. There is a strong need to address the remote working needs of users, especially over Internet, as they tend to monitor the systems by online services and prefer being informed about vulnerabilities, risks, or anomalies over online channels. This may bring authentication and authorisation problems and the protection of critical data about persons and infrastructures.

Competitors. There exist hardware-based security products already in the market promoted by the renowned companies, e.g., Thales, IBM, Cisco, Utimaco. The existing products are usually promoted as standalone devices, like HSM, security tokens or gateways. Big companies like Siemens promote large system-level solutions which are very expensive. ERARGE's strategy is to target the middle segment by promoting its hardware-based solutions in the form of a solution stack or solution family that can be tailored to different domains and support new open-source tools like FIDO, KeyCloak, etc.

Stakeholders. Within the context of VALU3S, primary stakeholders are the system integrators or industrial organisations which have their own integration teams. Secondary stakeholders are the SCP experts and the interim solution providers. ERARGE is aware of the decision-making processes applied by these stakeholders, which should consider the cost-effectiveness, compliance with standards, certification, online service delivery and maintenance and the technical consultancy to adapt our solutions to their actual needs.

Techy Ltd.

Organisation short name	TECHY	
Organisation type	SME	
Business model	B2C	
Key exploitable results	TECHY's ongoing development efforts toward a new suite of software products that consist of a toolset of an automated simulation environment which will offer V&V services to companies within the target domains by utilising the framework and know-how gained within VALU3S project.	

Results to be obtained from VALU3S. TECHY has been developing and tailoring its software toolset towards the local use case (UC11) needs in order to bring out a feasible robot verification and validation process. At the end of the project, TECHY aims to help reduce the cost, time and complexity regarding the objective requirements.

Identification of market share. Combination and further development of several open licensed software into an efficient and user-friendly V&V product that can be marketed within the industrial robotics sector. Cloud-based companies such as AWS, Google, and Microsoft offer services that can be deployed quickly but they require a steep learning phase and have comparatively high costs.

Key market drivers. Cross-border cooperation among industrial partners is a crucial element for a successful market entry. Lack of relevant legislation and corresponding standardization are main barriers.

Market trends. PaaS and SaaS approaches have gained much attention within the market. Verification and validation services should aim to become versatile, easily configurable to the needs and deployable, cost-efficient at the same time.

Users' profiles. User needs and preferences include controlling systems remotely, hassle-free integration with the underlying infrastructure, reduction in complexity, time, and costs.

Competitors. Testing-as-a-Service (TaaS) providers.

Stakeholders. System integrators, OEMs, Tier1s and Tier2s using industrial automated robotic systems.

A.3 Research and Technology Organisations (Use Case Contributors)

A.3.1 Automotive Domain

RISE Research Institutes of Sweden AB

Organisation short name	RISE	
Organisation type	Research Institute	
Business model	Non-profit research organization	
Key exploitable results	New knowledge and experiences on how to verify and validate the safety and security of automated- and ML-based safety critical-systems.	
Other domains	Aerospace	

Results to be obtained from VALU3S. Improved processes and tool chains for the methods "V&V of Machine Learning-Based Systems Using Simulators", "model-implemented fault and attack injection", and "simulation-based fault and attack injection". Knowledge on the infrastructure sensor systems and potential connection to vehicle sensors in connected mobility. Knowledge and experiences in V&V of ML-based systems in terms of safety, cybersecurity and privacy.

RISE enhanced the prototype research tool MODIFI with support for automatic dependability and security testing as well as pre-injection analyses that reduce the time and cost of fault and attack injection campaigns. MODIFI injects faults and attacks into Simulink models mainly used within the automotive and aerospace domains. RISE has also gained knowledge in real-world complex machine learning algorithms and the challenges of how to prove that they are safe and/or secure. RISE vision is to grow and become an international leading innovation partner and coordination of large EU-projects is one important step to achieve recognition and visibility. Moreover, through development of a simulation-based fault and attack injection tool, RISE is able to evaluate automated features such as platooning and adaptive cruise control by introducing communication faults and attacks, examples of which are jamming attacks and denial of service as well as delay attacks.

Identification of market share. RISE is the largest industrial research institute in Sweden with over 2 800 employees. RISE offers unique expertise and over 100 testbeds and demonstration environments for future-proof technologies, products, and services. In VALU3S, RISE's focus is on scientific publications and prototype research tools without any consideration about market shares.

Key market drivers. The use of ML-based systems in safety critical applications within the automotive industry is of high interest. However, ML-based systems have characteristics for which established systems engineering methods are less applicable. ML limits reproducibility, testability, and explainability and the corresponding safety standards are still under development.

Gained knowledge in this area will give RISE the opportunity to participate in new European research projects where it can collaborate with universities, research institutes and with European industry. Moreover, it contributes to solving issues that European companies face with.

Market trends. Will enrich RISE's testbed portfolios: AstaZero test track and RISE's initiative to evaluate approaches for AI/ML testing, i.e., the AIQ Meta-Testbed. Improved offers at RISE's testbeds can provide new opportunities for business development, as well as future research projects in Sweden and EU; Examples of these testbeds are the Cyber range [266] and the Cyber Test lab [267].

Also, as some of RISE's customers' demands training in V&V of safety and security for their automated systems, the VALU3S results will help RISE to develop new courses and services.

Users' profiles. Automotive industrial partners who want to test and certify their AV/ADAS products. The profile of RISE's customers, that ask for its services, are mostly OEMs and their subcontractors, and SME´s.

Competitors. Since each academic organization has their own profile, RISE rather sees them as possible collaborators instead of competitors.

Stakeholders. For example, legislators, automotive industrial partners, smart traffic infrastructure partners.

RISE is a State-owned research institute, so the main stakeholder is the Swedish government. Other stakeholders include a broad range of Swedish companies since RISE is a polytechnical research institute with over 10 000 customers.

Foundazione Bruno Kessler

Organisation short name	FBK			
Organisation type	RTO			
Business model	Non-profit research organisation			
Key exploitable results	Improved version of tools for formal verification and safety analysis.			
Other domains	Agriculture	Railway	Healthcare	Aerospace

Results to be obtained from VALU3S. FBK's tools and techniques are domain-independent and applied in the past across different domains. FBK provides nuXmv for model checking of infinite-state discrete-time and timed systems, KRATOS for software model checking of embedded C code, OCRA for contract- based design, xSAP for model-based fault injection and safety analysis, and NuRV for runtime verification.

Identification of market share. FBK's tools and techniques for V&V have been applied mainly in aerospace and railway, and more recently in automotive. FBK aims at strengthening the position in these domains and at expanding the application to domains such as agriculture and healthcare.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. The target users are companies that are willing to invest in technology transfer projects.

Competitors. There is a plethora of tools for model checking while, for model-based safety analysis and contract-based design, there are really few competitors. FBK tools provide scalable techniques that have been applied in industrial contexts and integrated in higher-level design environments such as CHESS. Moreover, they support rich specification languages based on temporal logic, including fragments of first-order linear temporal logic (FO-LTL), metric temporal logic (MTL), signal temporal logic (STL).

Stakeholders. Industrial partners.

Instituto Superior de Engenharia do Porto

Organisation short name	ISEP
Organisation type	Academic
Business model	B2C
Key exploitable results	The DSL for modelling and verifying safety-critical distributed systems.
Other domains	Railway

Results to be obtained from VALU3S. In the course of VALU3S, ISEP aims at developing a framework that enables the safe runtime verification of safety-critical applications. In the core of this objective lies a domain specific language where users can specify software components of the system (tasks), specify timing and criticality constraints, and also specify formal properties to be monitored while the target system executes. The domain specific parser, with support for tools present in the envisioned framework, will be responsible for checking that all specifications are correct and generate monitors for the formal specifications designed to that purpose. The framework aims at incorporating several runtime verification frameworks and generate the monitors based on the mapping of specifications to particular runtime verification frameworks.

Identification of market share. Research in the scope of formal verification of safety-critical computing systems.

Key market drivers. The success of the work to be developed in motivated by the lack of tools for verifying safety-critical systems while they execute. If the work succeeds as expected the framework that will come out of it can help contribute to the development of (even) safer safety-critical systems, and promote the dissemination of formal methods within industrial contexts.

Market trends. Automated systems, wherever the target domain, are growing in complexity and need stronger verification guarantees. Standards are promoting the introduction of formal methods-based techniques in the verification and validation processes.

Users' profiles. Engineers and Computer Scientists with a base knowledge of formal methods and monitoring.

Competitors. N/A.

Stakeholders. Companies working on Cyber-Physical Systems, in particular those in the safety-critical domain.

The Swedish National Road and Transport Research Institute

Organisation short name	VIT	
Organisation type	Research Institute	
Business model	Research organisation	
Key exploitable results	Knowledge in performing fault and attack injection in simulated environment, and a methodology to analysis how such faults propagate through a system.	

Results to be obtained from VALU3S. VTI has extended and improved tools for performing V&V in two use cases related to automotive domain. One of the tools allows a simulation-based fault and attack injection to be performed on wireless communication channels in order to verify and validate systems in the context of connected, cooperative and automated mobility. Another result is the development of an existing driving simulation platform to accommodate V&V process within automotive domain.

Identification of market share. Research within automotive sector.

Key market drivers. Systems within automotive domain are often validated and verified using simulation in an initial development phase. These improved tools would provide new approach to V&V process in this domain.

Market trends. An ability to offer new methodology using VTI's simulation facility.

Users' profiles. Organizations who need to conduct research using VTI's simulation facility.

Competitors. Organizations who own advanced moving-base driving simulator with the developed features.

Stakeholders. Use case owners can be the main stakeholders. VTI is a non-profit organization, so it does not aim to commercialize any product.

FRAUNHOFER IIS/EAS

Organisation short name	FRAUNHOFER IIS/EAS
Organisation type	RTO
Business model	Non-profit research organisation, Contract Research
Key exploitable results	-

Results to be obtained from VALU3S. The results FRAUNHOFER IIS/EAS expects to obtain are an improved methodology for HW/SW co-verification on different levels of abstraction. FRAUNHOFER IIS/EAS will develop automation solutions for verification and validation of adaptive systems.

Identification of market share. FRAUNHOFER IIS/EAS target market is the automotive and industrial market.

Key market drivers. For instance, in the automotive domain, the main drivers are automated driving and electrification. In the industrial domain, the concept of industry 4.0 drives the development.

Market trends. The automotive market is driven by a high demand for high-performance embedded systems. Reduction of the number of engine control units (ECUs) requires a higher integration density on a single ECU.

Users' profiles. FRAUNHOFER IIS/EAS 'users' are the SW and HW developers it works with. They are part of the automotive or industrial domains. Staying ahead of the fast industrial developments is the main challenge for a research institute.

Competitors. As a research institution around applied research FRAUNHOFER IIS/EAS do not have the usual market competition.

Stakeholders. FRAUNHOFER IIS/EAS primary 'stakeholders' are the companies that it works with. Their decision-making process is affected by the degree of innovation of FRAUNHOFER IIS/EAS products and services.

FRAUNHOFER IESE

Organisation short name	FRAUNHOFER IESE
Organisation type	RTO
Business model	Non-profit research organisation, Contract Research
Key exploitable results	Tool framework FERAL for virtual validation.
Other domains	Robotics

Results to be obtained from VALU3S. FRAUNHOFER IESE will make use of results achieved in the project, especially the improved version of the virtual validation framework FERAL. In the project, the institute has enhanced the existing simulation and validation capabilities of the FERAL framework with new domain-specific component types, tool connectors, and network models to support the automated validation of fault tolerance and robustness of software concepts and system architecture designs.

Identification of market share. The results address the automotive market.

Key market drivers. The key market drivers are electrification and autonomous driving.

Market trends. The complexity of software-intensive systems is growing due to the integration of systems from different domains and classes towards cyber-physical systems or digital ecosystems, which requires early validation of new features and architecture design decisions.

Users' profiles. Component developers, system architects, system integrators, OEMs and operators of complex software-intensive systems.

Competitors. As a research institution, FRAUNHOFER IESE competes with other applied research organizations in the fields of software engineering, systems engineering, and virtual engineering.

Stakeholders. Companies that design and develop complex software-intensive systems.

AIT Austrian Institute of Technology GmbH

Organisation short name	AIT
Organisation type	Research Institute
Business model	Contract Research, Licensing
Key exploitable results	V&V methods and tools testbed.

Results to be obtained from VALU3S. AIT's exploitable results are not focused on a specific domain. They are developed and evaluated in the context of use cases from the automotive and robotic/industrial control domain but can be applied to other domains.

AIT's main exploitable results in VALU3S will be the integration of a model-based testing solution with a modelling environment, safety and security risk modelling and a fault injection workbench. The integrated tools together will support new methods and approaches addressing safety and security testing aspects. They will be exploited together with the other partners contributing to the combined tool set, foremost LLSG.

AIT will also exploit the project results via dissemination of the results to the safety and security standardisation initiatives.

The set of patterns for applying the V&V methods developed by the partners together will be exploited in context of consulting and follow-up projects.

Identification of market share. The developed solutions address the generally growing markets of distributed cyber-physical systems – including among others, IoT-like solutions in railway and automotive and IoT for industry.

Key market drivers. Within the automotive domain, autonomous driving, intelligent traffic surveillance and electrification stand out.

Market trends. Automated systems are growing in complexity and require greater verification guarantees. Therefore, model-based testing is becoming increasingly relevant in this field.

Users' profiles. Component developers/suppliers, system integrators, OEMs and operators of cyber-physical systems.

Competitors. Model-based testing solutions are available from several sources, e.g., Conformiq, All4Tech, seep.med, Smartestint and others. None of them provide the integration with modelling tool, safety and security modelling, and fault injection environment AIT aims for in VALU3S. Also, the general method to combine model-based mutation testing and fault injection is new. The techniques developed in the project will also produce smaller and at the same time more thorough tests than available from the competitors.

Stakeholders. Companies working on Cyber-Physical Systems.

A.3.2 Agriculture Domain

Foundazione Bruno Kessler

Organisation short name	FBK			
Organisation type	RTO			
Business model	Non-profit research organisation			
Key exploitable results	Improved version of tools for formal verification and safety analysis.			
Other domains	Automotive	Railway	Healthcare	Aerospace

Results to be obtained from VALU3S. FBK's tools and techniques are domain-independent and applied in the past across different domains. FBK provides nuXmv for model checking of infinite-state discrete-time and timed systems, KRATOS for software model checking of embedded C code, OCRA for contract- based design, xSAP for model-based fault injection and safety analysis, and NuRV for runtime verification.

Identification of market share. FBK's tools and techniques for V&V have been applied mainly in aerospace and railway, and more recently in automotive. FBK aims at strengthening the position in these domains and at expanding the application to domains such as agriculture and healthcare.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. The target users are companies that are willing to invest in technology transfer projects.

Competitors. There is a plethora of tools for model checking while, for model-based safety analysis and contract-based design, there are really few competitors. FBK tools provide scalable techniques that have been applied in industrial contexts and integrated in higher-level design environments such as CHESS. Moreover, they support rich specification languages based on temporal logic, including fragments of FO-LTL, MTL, STL.

Stakeholders. Industrial partners.

A.3.3 Railway Domain

Foundazione Bruno Kessler

Organisation short name	FBK			
Organisation type	RTO			
Business model	Non-profit research organisation			
Key exploitable results	Improved version of tools for formal verification and safety analysis.			
Other domains	Automotive	Agriculture	Healthcare	Aerospace

Results to be obtained from VALU3S. FBK's tools and techniques are domain-independent and applied in the past across different domains. FBK provides nuXmv for model checking of infinite-state discrete-time and timed systems, KRATOS for software model checking of embedded C code, OCRA for contract- based design, xSAP for model-based fault injection and safety analysis, and NuRV for runtime verification.

Identification of market share. FBK's tools and techniques for V&V have been applied mainly in aerospace and railway, and more recently in automotive. FBK aims at strengthening the position in these domains and at expanding the application to domains such as agriculture and healthcare.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. The target users are companies that are willing to invest in technology transfer projects.

Competitors. There is a plethora of tools for model checking while, for model-based safety analysis and contract-based design, there are really few competitors. FBK tools provide scalable techniques that have been applied in industrial contexts and integrated in higher-level design environments such as CHESS. Moreover, they support rich specification languages based on temporal logic, including fragments of FO-LTL, MTL, STL.

Stakeholders. Industrial partners.

Instituto Superior de Engenharia do Porto

Organisation short name	ISEP
Organisation type	Academic
Business model	B2C
Key exploitable results	The DSL for modelling and verifying safety-critical distributed systems.
Other domains	Automotive

Results to be obtained from VALU3S. In the course of VALU3S, ISEP aims at developing a framework that enables the safe runtime verification of safety-critical applications. In the core of this objective lies a domain specific language where users can specify software components of the system (tasks), specify timing and criticality constraints, and also specify formal properties to be monitored while the target system executes. The domain specific parser, with support for tools present in the envisioned framework, will be responsible for checking that all specifications are correct and generate monitors for the formal specifications designed to that purpose. The framework aims at incorporating several runtime verification frameworks and generate the monitors based on the mapping of specifications to particular runtime verification frameworks.

Identification of market share. Research in the scope of formal verification of safety-critical computing systems.

Key market drivers. The success of the work to be developed in motivated by the lack of tools for verifying safety-critical systems while they execute. If the work succeeds as expected the framework that will come out of it can help contribute to the development of (even) safer safety-critical systems, and promote the dissemination of formal methods within industrial contexts.

Market trends. Automated systems, wherever the target domain, are growing in complexity and need stronger verification guarantees. Standards are promoting the introduction of formal methods-based techniques in the verification and validation processes.

Users' profiles. Engineers and Computer Scientists with a base knowledge of formal methods and monitoring.

Competitors. N/A.

Stakeholders. Companies working on Cyber-Physical Systems, in particular those in the safety-critical domain.

Ikerlan S. Coop.

Organisation short name	IKERLAN
Organisation type	RTO
Business model	B2B
Key exploitable results	V&V-centred methodologies and tools for computer vision and AI.

Results to be obtained from VALU3S. As a result of the project, IKERLAN will get methodology and tools that will accelerate V&V process of computer vision and AI enhanced system in the railway domain. The tools developed are DaGe4V and VATRA, the first one for accelerating the process of recording, which enables the connections and control with the simulator that can generate any type of environment or weather condition and the second one, is a domain-independent tool and thus it can be used for speeding up validation of computer vision systems in several domains, analysing AI/ML metrics and safety and also generates reports on those ones.

Identification of market share. IKERLAN's target market will be autonomous vehicle. More specifically, due to IKERLAN's wide experience in the railway domain, the R&D of IKERLAN is aimed at the development of automatic driving systems for railway and within VALU3S project a new way for simulating and validating happened.

Key market drivers. To apply the results of the project in the competitive railway domain, it is necessary to go hand with a train manufacturer. The exploitable results are expected to speed up the validation of the systems developed by the railway domain partner, so that they can be included in their development processes in order to facilitate the validation and certification of their systems.

Market trends. IKERLAN as a research centre must be in the scope of new technologies and due to its experience in testing and validation, VALU3S project enabled IKERLAN to get into a new era of testing and virtual validation. These improvements provide IKERLAN new opportunities for business development, as well as future research projects in the Basque Country and EU. It can also involve in new projects of different industrial partners.

Users' profiles. IKERLAN's target user for the expected results of VALU3S project is CAF group. Industrial partners from other domains such as industrial automation or warehouse management may also be potential targets.

Competitors. Most train manufacturers developers, together with their technology partners, are developing autonomous driving systems and need processes and tools to speed up the V&V of such systems. These autonomous driving systems are not open systems but proprietary and they generally require custom tools. IKERLAN's product is expected to be tailored to the needs of the railway domain partner in VALU3S project.

Stakeholders. Users, operators, suppliers, and providers related to the railway sector.

A.3.4 Healthcare Domain

Foundazione Bruno Kessler

Organisation short name	FBK			
Organisation type	RTO			
Business model	Non-profit research organisation			
Key exploitable results	Improved version of tools for formal verification and safety analysis.			
Other domains	Automotive	Agriculture	Railway	Aerospace

Results to be obtained from VALU3S. FBK's tools and techniques are domain-independent and applied in the past across different domains. FBK provides nuXmv for model checking of infinite-state discrete-time and timed systems, KRATOS for software model checking of embedded C code, OCRA for contract- based design, xSAP for model-based fault injection and safety analysis, and NuRV for runtime verification.

Identification of market share. FBK's tools and techniques for V&V have been applied mainly in aerospace and railway, and more recently in automotive. FBK aims at strengthening the position in these domains and at expanding the application to domains such as agriculture and healthcare.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. The target users are companies that are willing to invest in technology transfer projects.

Competitors. There is a plethora of tools for model checking while, for model-based safety analysis and contract-based design, there are really few competitors. FBK tools provide scalable techniques that have been applied in industrial contexts and integrated in higher-level design environments such as CHESS. Moreover, they support rich specification languages based on temporal logic, including fragments of FO-LTL, MTL, STL.

Stakeholders. Industrial partners.

A.3.5 Aerospace Domain

RISE Research Institutes of Sweden AB

Organisation short name	RISE	
Organisation type	Research Institute	
Business model	Non-profit research organization	
Key exploitable results	New knowledge and experiences on how to verify and validate the safety and security of automated- and ML-based safety critical-systems.	
Other domains	Automotive	

Results to be obtained from VALU3S. Improved processes and tool chains for the methods "V&V of Machine Learning-Based Systems Using Simulators", "model-implemented fault and attack injection", and "simulation-based fault and attack injection". Knowledge on the infrastructure sensor systems and potential connection to vehicle sensors in connected mobility. Knowledge and experiences in V&V of ML-based systems in terms of safety, cybersecurity, and privacy.

RISE enhanced the prototype research tool MODIFI with support for automatic dependability and security testing as well as pre-injection analyses that reduce the time and cost of fault and attack injection campaigns. MODIFI injects faults and attacks into Simulink models mainly used within the automotive and aerospace domains. RISE vision is to grow and become an international leading innovation partner and coordination of large EU-projects is one important step to achieve recognition and visibility.

Identification of market share. RISE is the largest industrial research institute in Sweden with over 2 800 employees. RISE offers unique expertise and over 100 testbeds and demonstration environments for future-proof technologies, products, and services. In VALU3S, RISE's focus is on scientific publications and prototype research tools without any consideration about market shares.

Key market drivers. ML-based systems have characteristics for which established systems engineering methods are less applicable. ML limits reproducibility, testability, and explainability and the corresponding safety standards are still under development.

Gained knowledge in this area will give RISE the opportunity to participate in new European research projects where it can collaborate with universities, research institutes and with European industry. Moreover, it contributes to solving issues that European companies face with.

Market trends. Market trends. Will enrich RISE's testbed portfolios: AstaZero test track and RISE's initiative to evaluate approaches for AI/ML testing, i.e., the AIQ Meta-Testbed. Improved offers at RISE's testbeds can provide new opportunities for business development, as well as future research projects in Sweden and EU; Examples of these testbeds are the Cyber range [266] and the Cyber Test lab [267].

Also, as some of RISE's customers' demands training in V&V of safety and security for their automated systems, the VALU3S results will help RISE to develop new courses and services.

Users' profiles. Automotive industrial partners who want to test and certify their AV/ADAS products. The profile of RISE's customers, that ask for its services, are mostly OEMs and their subcontractors, and SME´s.

Competitors. Since each academic organization has their own profile, RISE rather sees them as possible collaborators instead of competitors.

Stakeholders. For example, legislators and aerospace partners.

RISE is a State-owned research institute, so the main stakeholder is the Swedish government. Other stakeholders include a broad range of Swedish companies since RISE is a polytechnical research institute with over 10 000 customers.

Foundazione Bruno Kessler

Organisation short name	FBK			
Organisation type	RTO			
Business model	Non-profit research organisation			
Key exploitable results	Improved version of tools for formal verification and safety analysis.			
Other domains	Automotive	Agriculture	Railway	Healthcare

Results to be obtained from VALU3S. FBK's tools and techniques are domain-independent and applied in the past across different domains. FBK provides nuXmv for model checking of infinite-state discrete-time and timed systems, KRATOS for software model checking of embedded C code, OCRA for contract- based design, xSAP for model-based fault injection and safety analysis, and NuRV for runtime verification.

Identification of market share. FBK's tools and techniques for V&V have been applied mainly in aerospace and railway, and more recently in automotive. FBK aims at strengthening the position in these domains and at expanding the application to domains such as agriculture and healthcare.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. The target users are companies that are willing to invest in technology transfer projects.

Competitors. There is a plethora of tools for model checking while, for model-based safety analysis and contract-based design, there are really few competitors. FBK tools provide scalable techniques that have been applied in industrial contexts and integrated in higher-level design environments such as CHESS. Moreover, they support rich specification languages based on temporal logic, including fragments of FO-LTL, MTL, STL.

Stakeholders. Industrial partners.

A.3.6 Industrial Robotics/Automation Domain

FRAUNHOFER IESE

Organisation short name	FRAUNHOFER IESE
Organisation type	RTO
Business model	Non-profit research organisation, Contract Research
Key exploitable results	Tool framework FERAL for virtual validation.
Other domains	Automotive

Results to be obtained from VALU3S. FRAUNHOFER IESE will make use of results achieved in the project, especially the improved version of the virtual validation framework FERAL. In the project, the institute has enhanced the existing simulation and validation capabilities of the FERAL framework with new domain-specific component types, tool connectors, and network models to support the automated validation of fault tolerance and robustness of software concepts and system architecture designs.

Identification of market share. The results address industrial robotics/automation market.

Key market drivers. The key market driver is industry 4.0.

Market trends. The complexity of software-intensive systems is growing due to the integration of systems from different domains and classes towards cyber-physical systems or digital ecosystems, which requires early validation of new features and architecture design decisions.

Users' profiles. Component developers, system architects, system integrators, OEMs, and operators of complex software-intensive systems.

Competitors. As a research institution, FRAUNHOFER IESE competes with other applied research organizations in the fields of software engineering, systems engineering, and virtual engineering.

Stakeholders. Companies that design and develop complex software-intensive systems.

A.4 Universities (Use Case Contributors)

A.4.1 Automotive Domain

Vysoke Uceni Technicke V Brne – Brno University of Technology

Organisation short name	BUT
Organisation type	University
Business model	B2C
Key exploitable results	V&V methods and tools testbed.
Other domains	Healthcare

Results to be obtained from VALU3S. BUT will make use of results achieved in the project, especially improvement of V&V methods and applying tools developed in the project. These results will improve teaching courses, in particular courses about software testing and static analysis of software, research of V&V methods and tools, in particular static code analysis, fault-injection of network traffic, and runtime verification. The results obtained from VALU3S will also benefit when negotiating new partnership or commercialisation activities.

Identification of market share. The market share includes those which aim at monitoring of individual cars movement and monitoring and controlling of their driving system.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. Since BUT is a non-profit organization, there is no specific users.

Competitors. Since BUT is university and as such is non-profit organisation, there is no direct competitor. Indirect competitors may include other universities which offer similar courses and education, and research organisations which based their research on similar methods under the expertise of BUT.

Stakeholders. BUT managers, department managers and automotive industry.

A.4.2 Agriculture Domain

Universita Degli Studi Dell'Aquila

Organisation short name	UNIVAQ
Organisation type	University
Business model	Research
Key exploitable results	1) New methods for Intrusion Detection Systems in Wireless Sensor Networks and Fault Detection via Machine Learning and Kalman Filtering. 2) Results will be exploited via tests on the agriculture robot of the UC6 and a tool will be developed. 3) As an education institution UNIVAQ is not aware of possible impact on the market.

Results to be obtained from VALU3S. UNIVAQ will obtain a prototype software tool to detect faults and malicious attacks. In particular, such tool will implement:

1. An Intrusion Detection System to provide V&V features in Wireless Sensor Networks (WSN). This system will be able to detect malicious attacks in a WSN and notify the attempts to the entity responsible of providing reactions
2. A ML-based fault detector to detect systems' failures and attacks.

Identification of market share. UNIVAQ will provide a prototype software tool to detect faults and malicious attacks. In this respect, and as an educational institution, will contribute to the scientific research, with no specific target markets.

Key market drivers. The developed methodologies are scalable to generic WSN and complex CPS. Therefore, there is the opportunities that they spread both in the academic and industrial areas.

Market trends. The market that operates in the context of WSN and CPS security has gained a lot of attention in the last years. Several companies produce systems that can be the target of a cyber-attack. For this reason, there will be an high demand for the proposed tools and methodologies.

Users' profiles. Master degree and Ph.D. students, researchers, and company employees interested in the topic.

Competitors. As an education institution UNIVAQ is not aware of possible competitors.

Stakeholders. Universities, researchers, start-ups, companies.

Universita Degli Studi Di Genova

Organisation short name	UNIGE
Organisation type	University
Business model	B2B
Key exploitable results	-

Results to be obtained from VALU3S. It is expected that the outputs from VALU3S will contribute to improving the current state-of-the-art and the UNIGE knowledge about fault injection and anomaly detection techniques regarding the considered agriculture use case.

Identification of market share. Degree courses and industrial training courses that will be organised in the future.

Key market drivers. Although the methodologies applied may be adopted by a wide audience, they need to be designed also considering their possible future employment and comprehension from people not directly involved in the project in order to ease their spread.

Market trends. N/A.

Users' profiles. Degree students and industry employers interested in increasing their knowledge on the investigated topic.

Competitors. There could be other universities and research institutions which could organize training courses on the same topics. Each of these entities will exploit its own knowledge gained participating in different regional, national, or international research projects.

Stakeholders. N/A.

A.4.3 Railway Domain

Kungliga Tekniska Hoegskolan

Organisation short name	KTH
Organisation type	University
Business model	B2C
Key exploitable results	Healing Core methodology for FPGAs.

Results to be obtained from VALU3S. Although KTH will participate in BT's Safe function out-of-context use case (railway domain), its technology is not domain-specific. It can be used in any domain that have FPGAs in their products. KTH will develop its new Healing Core methodology for FPGAs further, raising it from TRL1 to TRL3.

Identification of market share. KTH's market share is first to publish papers around its technology. Its partner companies will evaluate its technology to see if it is commercially viable.

Key market drivers. Among its advantages, it is a methodology applicable in many domains. Among its disadvantages, it might be that the solution KTH provides is too costly to use in practice for smaller FPGA designs.

Market trends. N/A.

Users' profiles. Any user that uses FPGAs in its products that require handling of safety.

Competitors. FPGA vendors have components so users can put together and build similar products. However, some of the vendor components are far from optimal. KTH provides an integrated solution that is better than what exists on the market today.

Stakeholders. University managers, FPGAs users.

A.4.4 Healthcare Domain

Universidade de Coimbra

Organisation short name	COIMBRA
Organisation type	University
Business model	Research and teaching
Key exploitable results	V&V-centred systems engineering tool suite.

Results to be obtained from VALU3S. COIMBRA expects to develop the next generation of low intrusion fault injection tools and robustness testing tools, capable of injecting software faults (i.e., most common bug types), hardware transient faults and interface faults. The new version of the tools will automate and simplify the injection process, while address the paramount issue of fault coverage though the establishment of weighted realistic failure injection strategies.

Identification of market share. N/A.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. The user should not need to be knowledgeable of fault injection techniques and workflow to use the tools. The degree of automations must be high.

Competitors. There are no similar commercial tools.

Stakeholders. Academia and research centres, space agencies (where previous versions of the tools have been used), and companies developing software and systems for critical applications.

Vysoke Uceni Technicke V Brne – Brno University of Technology

Organisation short name	BUT
Organisation type	University
Business model	B2C
Key exploitable results	Advanced patient model for verification.
Other domains	Automotive

Results to be obtained from VALU3S. The main result in healthcare domain is an advanced model of a patient which has been used for verification/simulation purposes of infusion pump system. The model of a patient is the main part of a testing infrastructure – the core of the testbed.

Identification of market share. R&D medical devices, in particular those in early stage of development where no real patient can be used for testing purposes.

Key market drivers. N/A.

Market trends. N/A.

Users' profiles. Since BUT is a non-profit organization, there is no specific user.

Competitors. N/A.

Stakeholders. BUT managers, department managers and infusion pump system manufacturers.

Universidad de Castilla – La Mancha

Organisation short name	UCLM	
Organisation type	University	
Business model	Research and Education	
Key exploitable results	V&V-centred systems engineering tool suite. Assurance & certification-targeted approach and tool support for automated system V&V.	
Other domains	Robotics	

Results to be obtained from VALU3S. From a technical perspective, the main exploitable results by UCLM will be (1) V&V-centred systems engineering tool suite that meets assurance standards' requirements from several domains (aerospace, automotive, defence, healthcare, railway…), and (2) Assurance & certification-targeted approach and tool support for automated system V&V that exploits AI, semantic technologies, and model-based techniques.

Identification of market share. Since UCLM is an academic institution, its main market and customers correspond to 1) students, who can acquire VALU3S-related knowledge; 2) research community, which can gain new knowledge and identify new research gaps; 3) standardisation organisations, to which VALU3S results could be transferred; 4) companies, with which technology transfer contracts might be signed.

Key market drivers. There exists a relevant opportunity in the fact that it is expected that the safety-critical systems sector expands in the UCLM area.

The main possible barrier is that the results developed are not mature enough for industrial needs.

Market trends. There exists an increasing interest in and need for model-based, digital twin-based, and AI-based solutions for systems & software engineering, in education, research, and industry, and considering regulatory aspects.

Users' profiles. Based on the aforementioned, user profiles will be highly correlated with market share. 1) students, who can acquire VALU3S-related knowledge; 2) research community, which can gain new knowledge and identify new research gaps; 3) standardisation organisations, to which VALU3S results could be transferred; 4) companies, with which technology transfer contracts might be signed.

Competitors. Other research institutions working on similar solutions include Malardalen University (Sweden), Tecnalia (Spain), and University of York (UK).

Stakeholders. UCLM managers, automated system manufacturers, automated system component suppliers, tool vendors, certification authorities, system assessors, researchers.

A.4.5 Aerospace Domain

National University of Ireland Maynooth

Organisation short name	NUIM
Organisation type	University
Business model	Research and Education
Key exploitable results	V&V tools for requirements elicitation and traceability

Results to be obtained from VALU3S. NUIM's results focus on improved safety and performance of the aircraft engine and engine controller pair with respect to sensor faults, system parameter perturbation, hazardous events as well as faults detection, isolation, and recovery. In particular, we focus on the development of tool support for capturing system requirements and verifying safety properties of the system.

Key market drivers. Among the main opportunities, the application of new V&V methodologies in engine control stands out. On the other hand, the scalability of these methodologies will be complex.

Market trends. Services to support elicitation and documentation of detailed software requirements so that software failure can be avoided and/or understood.

Users' profiles. Safety Critical Software Developers

Competitors. Since NUIM has collaborated closely with UTRCI, who are the domain experts, it has relied on their expertise regarding competitive products for the Aerospace industry.

Stakeholders. NUIM's role in VALU3S has been primarily to support UTRCI. As such, they are the primary stakeholders. NUIM researchers and students, certification authorities and system assessors are also stakeholders. Our tools and techniques are applicable in all software development where requirements need to be formalised and verified for the final system.

A.4.6 Industrial Robotics/Automation Domain

Eskisehir Osmangazi Üniversitesi

Organisation short name	ESOGU
Organisation type	University
Business model	Research and Education
Key exploitable results	A run-time verification system for safety and security of industrial robots.

Results to be obtained from VALU3S. ESOGU will obtain results for Verification and Validation of Robotics systems. The developed methods and concepts could be used for various stakeholders in Robotics field. The tools will bring wide range of test capabilities for safety of robots.

Identification of market share. The worldwide market size of industrial robots was assessed at $ 41 billion in 2017 and is expected to grow up to reach $ 73 billion by 2023.

Key market drivers. The expected increase in market size of industrial robots has a great opportunity. On the other hand, the safety and security issues of industrial robots are the main barriers in this area.

Market trends. The expected increase in market size of industrial robots has a great opportunity for MARVer tool that designed for V&V of robotic systems. The safety and security issues of industrial robots are the main barriers that to be solved.

Users' profiles. Companies interested in our research results (technology transfer, new research projects, etc…).

Competitors. There is not a similar approach currently in the market.

Stakeholders. The primary stakeholders are OEMs, Tier1 and Tier2 companies.

Organisation short name	UCLM
Organisation type	University
Business model	Research and Education
Key exploitable results	V&V-centred systems engineering tool suite. Assurance & certification-targeted approach and tool support for automated system V&V.
Other domains	Healthcare

Results to be obtained from VALU3S. From a technical perspective, the main exploitable results by UCLM will be (1) V&V-centred systems engineering tool suite that meets assurance standards' requirements from several domains (aerospace, automotive, defence, healthcare, railway…), and (2) Assurance & certification-targeted approach and tool support for automated system V&V that exploits AI, semantic technologies, and model-based techniques.

Identification of market share. Since UCLM is an academic institution, its main market and customers correspond to 1) students, who can acquire VALU3S-related knowledge; 2) research community, which can gain new knowledge and identify new research gaps; 3) standardisation organisations, to which VALU3S results could be transferred; 4) companies, with which technology transfer contracts might be signed.

Key market drivers. There exists a relevant opportunity in the fact that it is expected that the safety-critical systems sector expands in the UCLM area.

The main possible barrier is that the results developed are not mature enough for industrial needs.

Market trends. There exists an increasing interest in and need for model-based, digital twin-based, and AI-based solutions for systems & software engineering, in education, research, and industry, and considering regulatory aspects.

Users' profiles. Based on the aforementioned, user profiles will be highly correlated with market share. 1) students, who can acquire VALU3S-related knowledge; 2) research community, which can gain new knowledge and identify new research gaps; 3) standardisation organisations, to which VALU3S results could be transferred; 4) companies, with which technology transfer contracts might be signed.

Competitors. Other research institutions working on similar solutions include Malardalen University (Sweden), Tecnalia (Spain), and University of York (UK).

Stakeholders. UCLM managers, automated system manufacturers, automated system component suppliers, tool vendors, certification authorities, system assessors, researchers.

Mondragon Goi Eskola Politeknikoa, JMA, S. Coop.

Organisation short name	MGEP
Organisation type	University
Business model	B2C
Key exploitable results	Training and consultancy services around simulation-based testing and test case generation involving human in a collaborative working environment with a robot.

Results to be obtained from VALU3S. After the accomplishment of VALU3S, MGEP will have the following results available for exploitation: 1) simulation-based testing framework that integrates an interactive system for simulating the behaviour of workers and algorithms for test case generation and, 2) an approach for simulation-based testing involving human worker in a Human-Robot collaboration context. These results will help MGEP to strengthen its position as training and consultancy provider as well as improve the provided courses in master and degree level, resulting in improved education of Europe's next generation of system engineers.

Identification of market share. MGEP's main market shares are students at the university and robotic industry companies.

Key market drivers. Collaborative robotics is currently in the spotlight. Collaborative robots offer certain advantages over conventional robotics and do not limit the human task but complement it. Therefore, specialising in the field of V&V in this new market niche can mean an increase in the services that the university can offer. However, in this case, the use case to be worked on is quite specific, which may limit the number of customers.

Market trends. The market for collaborative robotics is expected to increase considerably in the coming years, where several companies will include such robots in their production lines. This trend towards the use of these devices will bring with it a high demand for verification and validation processes.

Users' profiles. MGEP will address two users' profiles. On the one hand, students of the university (results will be used to enhance or develop courses in the context of teaching activities at the University). On the other hand, companies to whom industry courses and consultancy services to help into the introduction of the solutions developed in the project will be offered.

Competitors. Other universities and research centres that can provide similar products and services. The main difference among them and MGEP is MGEP's close collaboration with industry and its previous experience in simulation-based testing and test case generation.

Stakeholders. Key stakeholders include university and department managers, automated system manufacturers, disassembly companies and researchers.

Appendix B Life After VALU3S – How to Approach the Targets and Activities

This Appendix gathers the aspects of each of the targets and activities identified in Chapter 5.

B.1 Exploitation of Key Results

Benefit

- One benefit is the opportunity to create connections among partners and potential customers. The establishment of a European company provides a platform for cross-border cooperation and networking, which can lead to increased business opportunities and growth.
- In addition, a European company provides a more straightforward way to conduct business across multiple EU countries. This can result in greater efficiency and cost-effectiveness, as there are fewer legal and administrative barriers to contend with.
- Another benefit of establishing a European company is the increased mobility within the single market. A European company can take advantage of the freedom of establishment and freedom to provide services that are enshrined in EU law. This can lead to increased flexibility and agility in adapting to changing market conditions. Furthermore, a European company can establish a framework system for involving staff employed in more than one country. This can facilitate communication and coordination among staff members, regardless of their location, and ensure consistency in the company's operations.
- Overall, the establishment of a European company based on the European Company Statute can provide several benefits, including increased connectivity, efficiency, mobility, and staff involvement.

Incentive

- One incentive for companies to participate in the creation of a European company is the opportunity to obtain shares that entitle the holders to partake in the profits of the spin-off. By holding these shares, participating companies stand to benefit financially from the success of the new entity, thereby providing a tangible return on their investment in the creation of the European company. This incentivizes companies to contribute to the development and growth of the spin-off, as their efforts are directly tied to the financial rewards that can be gained through their ownership of these shares. Overall, this incentivizes collaboration and promotes a mutually beneficial outcome for all participating companies in the creation of the European company.

Service Quality Assurance

- The concept of service quality assurance is integral to the success of any business ecosystem. In the context of an ecosystem comparable to consultancies, services provided would be tailored to specific use cases while adhering to a general structure. This structure is composed of several key steps:

- A thorough understanding of the customers' needs and objectives.
- Definition of the requirements for the V&V of the system under. This step is critical to ensuring that the system meets all necessary standards and functions as intended.
- Selection of approaches, methodologies, and tools for use in the evaluation process. These approaches may be customised to suit the specific requirements of the use case.
- Following the selection of approaches and tools, these would be applied to the use case to initiate the testing campaign. This application of tools and methodologies would involve the systematic evaluation of the system under examination, with a focus on identifying and addressing any issues or potential areas for improvement.
- Finally, upon successful completion of the testing campaign, the validated system would be delivered to the customer.

Promotion

- Portfolio of successful use cases within the project, which serves as evidence of the project's V&V methods and tools. This portfolio provides tangible examples of how the VALU3S framework can be applied in real-world settings and helps to build trust and confidence in the project's approach.
- VALU3S counts in a comprehensive business plan with a marketing plan that could be easily adapted to the Ecosystem of Services.
- The marketing plan describes all the important aspects of the marketing strategy, which includes the market research conducted for the project, the strategies to be applied, the marketing objectives to be achieved and the actions and indicators to measure the obtained results. The marketing plan is divided into the following three phases:
    1. Analytical marketing, where the research or analysis of the competition and the market is conducted.
    2. Strategic marketing, where the strategy and objectives are defined.
    3. Operational marketing, where the actions to achieve the defined objectives are determined (company's website, advertisements in social media...), as well as the indicators for their correct monitoring and control and their continuous evaluation.

Consolidation

- To ensure the long-term viability of the Ecosystem of Services, four main exploitation lines have been identified as the foundation of the business. These exploitation lines would generate the necessary revenues to cover basic costs, invest in partner expansion, and develop better products and services:
    - Direct service delivery to the early customers through VALU3S toolbox.
    - Direct service delivery to new customers through VALU3S toolbox.
    - Licensing to system integrators of VALU3S toolbox. This approach offers the potential for broad adoption of the VALU3S methodology and the widespread promotion of sustainable business practices.
    - Organisation of events. The European company would leverage its expertise to host events. These events would serve as a platform for networking, sharing knowledge and expertise, and raising awareness about VALU3S framework and the Ecosystem of Services.

- As an international European interest organisation, the company may also consider applying for a Coordination and Support Action (CSA) in future initiatives. The funding obtained through a CSA could support the development of open-source tools or even the organisation of events, further expanding the reach and impact of the Ecosystem of Services.

Organisational Structure

- Under the conditions laid down in the Regulation, the organisational structure of the European company shall consist of two main bodies: a general meeting of shareholders and either a supervisory board and a management board (dual system) or an administrative board (single system), depending on the option adopted in the article of association:
    - The general meeting of shareholders would be responsible for making important decisions related to the European company, such as the appointment of members to the supervisory or administrative board, as well as the approval of the company's annual accounts.
    - If the dual system was adopted, the supervisory board would be responsible for monitoring the management board's activities and providing guidance on the company's overall strategy. The management board would have the power to manage the company's daily operations, as well as to make important decisions related to the company's activities.
    - Alternatively, if the single system was adopted, the administrative board would be responsible for both the strategic and daily management of the European company.

Legal Aspects

- In case the spin-off was a European company based on the European Company Statute, it would have to comply with two pieces of legislation:
    - Regulation (EC) No 2157/2001 on the Statute for a European Company. It introduces a legal framework for public limited liability companies to be set up within the territory of the EU so that they can plan and perform the reorganisation of their business on an EU-wide scale as well as in countries belonging to the European Economic Area.
    - Directive 2001/86/EC supplementing the Statute for a European Company with the regard to the involvement of employees. It supplements the regulation to ensure that the creation of a company does not lead to the disappearance or reduction of existing employee involvement practices in the companies involved in the creation of that company, given the diversity of rules and practices in different EU countries as regards the way in which employee representatives are involved in company decision-making.

B.2 Project's Website

Overall Benefit

- Advertise existing and new results. Effective advertising can help to create greater visibility and awareness of the project's contributions to the industry, thereby promoting its success and creating a positive impact.

- Advertise partners and contributors. This can help to establish a network of connections and collaborations among the project's stakeholders, as well as to attract new partners and contributors for future initiatives.

Overall Incentive

- Increase the visibility of the responsible partner(s) or member(s). This can serve as a motivating factor, encouraging these partners to continue contributing to the project's success and striving for excellence in their work.

B.2.1 Operate the Project Website

Benefit

- Links to the project website are kept alive. Maintaining live links to the project website is critical in ensuring that stakeholders have access to up-to-date information about the project.
- Public deliverables are kept accessible. The website provides a repository of valuable information, and keeping it accessible is important for ensuring that the project's findings and outcomes can be shared with the wider community.
- Contributors to VALU3S can be found and acknowledged. By maintaining a list of contributors and their contributions, the website allows for the skills and expertise of project partners to be showcased and advertised. This can serve as a valuable networking tool, connecting partners with similar interests and expertise.
- Skills of the partners (organisations and persons) are advertised. This can help to attract potential collaborators and promote the capabilities of the project's partners.
- A list of project publications is kept; otherwise, publications can be mapped to VALU3S only through their acknowledgement sections. By maintaining a list of publications, the website allows for the easy identification and access of project findings and outcomes. This can help to promote the project's impact and raise its profile within the industry.

Incentive

- Operational responsibility for the project website offers an opportunity for the responsible partner to gain extra visibility and reputation. The website serves as a showcase of the partner's capabilities and technical expertise, which can be beneficial for its brand and future collaborations.

Technology notes

- The website may require technical updates to WordPress to ensure its continued operation and security.

Legal aspects

- The funding organisation has a legal obligation to maintain the website for up to 5 years after the project. Therefore, the responsible partner should ensure the website's continuity and accessibility within this timeframe, complying with legal requirements and contractual obligations.

B.2.2 Maintain the Content of the Project Website

Benefit

- Maintenance of the complete picture of the results, also including results approved after the project.
- Putting VALU3S into the line of recent V&V related projects, increasing its visibility and relevance.
- Disseminate evidence of impact, e.g., number of citations, number of downloads, associated awards, number of projects or partners using a given work.
- Future projects can clearly see what has already been addressed and what lines of research or gaps remain open.
- Up-to-date information keeps readers longer and/or more often on the site.
- The ranking of internet search results is expected to be higher if the content is kept updated.

Incentive

- More control over data updates. Maintainers can ensure that the information on the website is always up-to-date, which can lead to faster dissemination of their own work. This can be particularly important in rapidly-evolving fields, where staying ahead of the competition is crucial.
- Maintainers may act as intermediates in technology transfer for new industrial connections. By keeping the website updated with the latest project developments and results, maintainers can help facilitate connections between interested industrial partners and project contributors, potentially leading to new collaborations and opportunities for both parties.
- When the website is hosted by an institution able to provide training, this institution can engage with the results advertised on the website. This can lead to the training of new researchers and practitioners in the field, increasing the impact and relevance of the project.
- Maintainers can refer to the website as a good reference of their own work. maintainers can showcase their expertise in the field, potentially leading to new collaborations and opportunities for themselves.

Moderation

- A *moderator* is someone who:
    - updates the website with minimal quality control, and
    - nominates an *Editorial Board* to assist with the quality control when needed. The role of the Editorial Board is to assist the moderator with quality control when needed. The Board should be composed of individuals with expertise in the subject matter and should work collaboratively with the moderator to ensure the content on the website is accurate, up-to-date, and relevant to the project.
- RISE will serve as the initial moderator for the project website, and all partners will provide content for the website initially.
- Moderation should be lightweight – mainly to ensure that the content:
    - is related to VALU3S,
    - does not taint the projects' reputation, and

- conforms to legal framework including the dissemination regulation in Grant Agreement (GA).

Content Quality Assurance

- Content will be reviewed before being made public to ensure that it is relevant to the VALU3S project and does not contravene any legal frameworks, including those outlined in the GA.
- The quality of the content of all the "dynamic"[5] sections of the webpage (e.g., *Deliverables*, *News*, *Publications*) needs to be maintained through regular reviews.
- An *Editorial Board* will be nominated by the *Moderator*, who will:
  - be assigned the task of reviewing specific entries by the *Moderator*,
  - be responsible for the quality of the content of these entries,
  - provide the feedback over these entries back to the Moderator, who will update the website or interact with the authors.

Presentation Quality Assurance

- The quality of the presentation of the full website will be maintained, and not only the "dynamic" sections of the webpage (e.g., this also applies to the *Partners*' section).
- Technical updates to WordPress or to other underlying technologies will require a new revision of the presentation quality.
- In order to ensure that the website is visually appealing, and informative, the following presentation aspects will be regularly reviewed and updated:
  - the way the information is displayed to the visitors of the website,
  - the links that are present to ensure that they are functional and relevant,
  - the authors and participants who are listed, and
  - graphical elements such as images and diagrams that are used to enhance the presentation of the website.

Promotion

- Updates can be advertised in social media channels already in place, among others. This will ensure that the project's latest developments and achievements are shared with a wider audience, thereby increasing its visibility and impact.
- Individual tools and methods developed within VALU3S can refer to the website as a primary source of information. This will not only help to ensure that these tools and methods are used and applied more widely but also increase the website's traffic and search engine rankings.
- Dissemination will also take place through public authorities and policy makers. By promoting the project to these stakeholders, VALU3S can raise awareness of its objectives and outcomes, potentially leading to further collaborations and funding opportunities.

Other Social Media Platforms

- Other media platforms other than the website, such as existing social platforms used by VALU3S (YouTube, Twitter, and LinkedIn) can be maintained together with the website.
- These will be interconnected:
  - news posted to the website can be promoted via Twitter and LinkedIn,

[5] A *dynamic* section is a part of the website that has content that is frequently updated, such as a news section.

- videos added to VALU3S' YouTube channel can be linked on the website and promoted via Twitter and LinkedIn,
- other social platforms can be considered in the future, based on the evolution of social media.

Consolidation

- The *Publications* section of the website should be regularly updated with links to publications related to the VALU3S project. This will help to keep the website visitors informed of the latest research outcomes and findings. Maintainers should ensure that the publications are linked to their respective authors, providing due credit and acknowledgement to their work.
- The *News* section of the website is a crucial means of informing the community about VALU3S developments and achievements. Maintainers should update this section with posts about:
  - projects using the results,
  - use cases and scenarios that apply the results,
  - other experiments that use the results, and
  - dissemination events that refer to VALU3S.

Legal Aspects

- The website should include a copyright statement that reflects the duration of the project. This statement should read "*Copyright © 2020-2023 VALU3S consortium*" and should be updated annually to reflect the current year.
- Ensure that licenses for included material (e.g., images) are updated and in accordance with what is defined by the authors. Any usage of external resources must comply with their licensing terms and conditions.

B.3 Web-based Repository

Overall Benefit

- User-friendly framework standardising V&V processes for automated systems.
- The framework is designed to be flexible enough to be applicable across different domains, providing a reliable and consistent methodology for V&V activities. By hosting useful information about V&V activities, the framework can help promote more efficient, accurate, and cost-effective development of automated systems. This, in turn, can lead to increased confidence in these systems, resulting in greater uptake by end-users and increased potential for impact in society.

Overall Incentive

- Benchmark of V&V methods and tools in automated systems. The framework has been tested across different domains and hosts useful information about V&V activities, enabling its users to make informed decisions about the applicability of methods and tools in their respective domains.
- Increase the visibility and reputation of the contributing partner(s) or member(s).

- Create connections between the partner(s) and future customers. By facilitating communication and information sharing, the website can help foster new partnerships and opportunities for the contributors.
- Other alternatives considered but that would need to be further investigated:
    - financial incentives,
    - requirement of a membership fees for maintenance costs,
    - apply for a CSA, to have funding to maintain content and infrastructures by industrial partners.

Overall Content Quality Assurance

- Content will be reviewed before being made public.

Overall Promotion

- The web-based repository will be promoted through scientific publications.
- New updates and add-ons can be advertised in social media channels already in place and in VALU3S' website.
- Dissemination will also take place through public authorities and policy makers. This will increase the visibility and reputation of the contributing partners or members, create connections between the partners and potential customers, and ultimately contribute to the successful adoption of the VALU3S framework.

Overall Legal Aspects

- Licenses:
    - Ensure that the licenses for included as well as updated material (e.g., images) are up-to-date and in accordance with what is defined by the authors.
    - Copyright matters could also be communicated with the users of the repository through the license information.
- Responsibility for completeness/correctness of content:
    - We would need to write a disclaimer informing the users about implications of the usage of the elements of the repository so that we are not to blame for any misuse. The text should be simple, similar to the standard texts used in project agreements. Moreover, the text should be as comprehensive as possible. We should also mention that the content of specific method is owned by a certain company so contact information could also be included there. Another term that could be included here is "for experimental use".

B.3.1 Web-based Repository Infrastructure

Benefit

- Common and standardised framework for the presentation of multiple improved V&V methods and tools applied across different domains. This consistency enables easier evaluation and benchmarking, leading to the identification of best practices and areas for improvement.
- Reduced dissemination costs by bringing all partners' results into a single overall and comprehensive output. Thus, it is possible to increase knowledge exchange and transfer.

- Sales lead (potential sales contact) interested in tailor-made V&V-centred systems engineering tool suite. This can attract potential customers interested in tailor-made solutions based on the common framework and the experiences gained from its implementation. As a result, the framework can enhance the visibility and commercial viability of V&V-centred systems engineering tool suites.

Presentation Quality Assurance

- The quality of the presentation of the web-based repository will be maintained, namely user interface. These quality checks will be conducted by a team of experts who specialised in user experience and interface design.
- The repository should be reachable via the VALU3S website; therefore, the presentation quality of the website should also be assured.

New Features

Benefit

- Laying further foundations for the benchmark in V&V of automated systems. This means that the repository will serve as a reference point for researchers and practitioners working in the field, providing a valuable resource for developing and testing automated systems.
- More detailed framework including aspects not covered in the original version of the repository. This means that the repository will be more comprehensive, providing users with a broader range of resources and tools to improve their work. This, in turn, will increase the repository's relevance and usefulness, making it an even more valuable resource for those practitioners working in the field.
- Increase repository's traffic visits. Increased traffic will result in higher visibility and exposure, which will help to establish the repository as a leading resource in the field. This, in turn, will attract more researchers and practitioners, increasing the repository's impact and contribution to the V&V of automated systems.

Incentive

- Adding features that are more relevant to the core activities of the partner organisations involved. This will ensure that the repository is aligned with the needs of its primary maintainers.
- Feeding back wishes of potential/current customers directly into the repository. Collecting feedback will help to identify areas for improvement and further customization, enhancing the repository's relevance and appeal.

Content Quality Assurance

- Quality of the content should be checked in case of new data being added. By conducting these checks, it is ensured that the repository remains a trusted source of information for researchers and practitioners in the field of V&V.

Presentation Quality Assurance

- New features added should be visually appealing, user-friendly, and consistent with the overall design of the repository. Therefore, the presentation of new added features needs to be revised,

possibly accompanied by specific guidelines on how to use them and how to browse the repository.

Consolidation

- New plug-ins shall be fully functional and integrated into the existing structure of the V&V framework. This will help to ensure that the repository remains a cohesive and coherent resource for its users, enhancing its overall value.

Technology notes

- Possible limitations due to Plone CMS troubleshooting should be considered. By being aware of these limitations, it is possible to address them proactively and ensure that the repository's technology remains reliable and effective.

Operate the Web-based Repository

Benefit

- Constantly updated web-based repository platform. This will ensure that the repository remains relevant and a reliable and valuable resource for researchers and practitioners alike.
- Improve the Search Engine Optimization of the repository. This will make the repository more easily discoverable and accessible to users.
- Increased credibility and trustworthiness of the repository and its content. This, in turn, will increase users' confidence in the repository's resources and tools, making it a more trusted and valuable resource in the field of V&V of automated systems.
- Future projects can clearly see what has been already addressed and what it is still open. By maintaining a clear record of what has been addressed, future projects can benefit from the repository's resources and avoid duplicating previous efforts. This will help to streamline research and development efforts in the field of V&V, ensuring that resources are allocated efficiently and effectively.

Incentive

- Responsible for operations is advertised as such, providing extra visibility and reputation.
- Possibility of having an active involvement in future initiatives directed towards usage as well as extension of the repository. This will give responsible parties a voice in the repository's development, allowing them to shape its future direction and ensure that it remains relevant to their needs.

Technology notes

- The technology used to build the repository may become obsolete or need new functionalities.
- Technical updates to Plone CMS might be needed to keep the repository operational and secure.

Legal Aspects

- Payment of repository’s domain name.
- New options to migrate the repository and change its structure should be considered.

Testing

Benefit

- Verify and validate that the web-based repository functionalities are operational, secure, and up to date, providing users with a reliable and user-friendly experience.
- Ensure the quality of the repository.
- Maintain data integrity, which is essential for ensuring the repository's credibility and trustworthiness.

Incentive

- Carrying out regular testing of the repository also provides an opportunity for partners to become more involved in its development and maintenance. Responsible parties that take an active role are advertised as such, providing extra visibility and reputation.
- Possibility of having an active involvement in future initiatives directed towards testing of the repository.

Technology notes

- Automated testing should be attempted as far as possible, as this can help to save time and ensure consistency in the testing process.
- Periodic manual testing shall also be carried out to ensure that the repository is thoroughly and comprehensively tested.

B.3.2 Maintain the Content of the Web-based Repository

Benefit

- Maintenance of the complete picture of the repository, also including results accomplished after the project.
- Future projects can clearly see what has been already addressed and what lines of research or gaps remain open, so that they save time and resources and contribute to more efficient and effective research.
- Updated information makes users visit the repository more frequently and increase their engagement. Users are more likely to visit and utilise a repository if they know that it contains the most recent and relevant data. This, in turn, can lead to increased collaboration, new ideas, and further advancements in the field.
- Improve the Search Engine Optimization of the repository. This crucial for ensuring that the repository is easily discoverable and accessible to a wider audience. By including relevant keywords and updating content regularly, the repository can rank higher in search engine results, making it more visible and accessible to researchers, practitioners, and other stakeholders.

Incentive

- Maintainers can have more control over data updates and faster dissemination of their own work. By maintaining the repository content, the maintainers can regularly update the data it contains, ensuring the stakeholders can easily access the latest research. In this way, maintainers can play a more active role in the dissemination of their own work, rather than relying on external sources to share their findings.

- Maintainers may act as intermediates in knowledge exchange for new industrial connections. Maintainers can provide a valuable resource to individuals and organisations seeking to stay up-to-date with the latest developments in their field. This can lead to new collaborations.

Moderation

- Initially conducted by RISE and MGEP as the organisations hosting the repository.
- It is expected to be subsequently conducted by a spin-off derived from VALU3S or a designated *technical board*.
- The repository is expected to be a publicly filled resource. Similar to Wikipedia's approach, it is intended that anyone can participate in the population of the repository.
- The appointed technical board will be responsible for conducting a peer review process of the external inputs.
- It is expected to establish reviewers, a committee, and a publisher for each review. Review accounts should be personal.
- Accepted external content shall have an associated legal liability. The designated technical board will hold the responsibility of ensuring that the content meets the required standards before publication.

Content Quality Assurance

- Content will be reviewed before being made public.
- A technical board will be nominated to ensure:
    - content quality including terminology in accordance with the vocabulary (Section 5.6),
    - soundness of structure and completeness,
    - all links are accessible, and
    - the content of the use cases and V&V methods and tools are thoroughly mapped.
- The technical board will propose a procedure to review (peer review process) and maintain the content. The peer review process will involve a thorough review of the content by a team of subject matter experts to ensure its accuracy and completeness. Once the content has been reviewed and approved by the peer review team, it will be published in the repository for public access.

Presentation Quality Assurance

- The following presentation aspects will be kept updated to maintain quality:
    - How information is displayed. This will involve reviewing and updating the formatting of the information to ensure that it is presented in a clear, concise, and consistent manner.
    - How users interact with the repository. The user interface will be reviewed regularly to identify any areas that need improvement and to ensure that it remains up to date with the latest design trends and user expectations.
    - Authors and participants. This will involve ensuring that their contributions to the repository are properly attributed and that their profiles are up to date. This will help users to identify the authors of the content they are reading and to engage with them directly if they have any questions or comments.

- Graphical elements, such as images, charts, and diagrams. This will involve ensuring that they are of high quality and that they add value to the content they accompany.

Promotion

- Updates can be advertised in social media channels already in place, among others. By using social media, these updates can reach a broader audience, including researchers, policy makers, and practitioners.
- Individual V&V methods and tools can also be advertised in VALU3S website. This will help researchers, policy makers, and practitioners to access the repository's content and tools easily.
- Dissemination will also take place through public authorities and policy makers. This will involve collaborating with relevant organisations and public authorities to ensure that the repository's content is shared widely among practitioners. By doing so, the repository can play a critical role in shaping policy decisions and driving innovation in the field of V&V.

Consolidation

- Maintainers should update the content of the repository. The maintainers will be responsible for ensuring that the repository's content is accurate, comprehensive, and reflective of the latest developments in the field of V&V.
- Some of the specific foreseen maintenance includes, but is not limited to, adding, and updating:
  - New or improved V&V methods, workflows, and tools. This will ensure that the repository remains a comprehensive resource for researchers, policy makers and practitioners. Maintainers will be responsible for categorising and describing new methods, workflows, and tools.
  - Repository dimensions and layers. These dimensions and layers may evolve as new V&V methods, workflows, and tools are developed, and it is the maintainers' responsibility to ensure that the repository accurately reflects these changes.
  - Data on the evaluation criteria measured. The maintainers will also ensure that the repository accurately reflects the latest evaluation criteria and that the data included in the repository is comprehensive and up-to-date.

Legal Aspects

- Write-up of a new agreement regulating the maintenance, usage, etc. of the repository:
  - In general, the current Project Cooperation Agreement (PCA) regulates the joint results obtained within the project. However, we would need to write a new agreement with the project partners and go into the details of the repository in that agreement. It is for example in that agreement that we could specifically indicate the background information of each of the project partners (in the background section), which is basically what they have already included in the latest version of the repository. So, it might not be that important at this point for every content to be tied to a person since we would need to clearly specify this in the new agreement. In any case, it is beneficial to already label them with the organisation who provided the information to make the finalization of the new agreement smoother.
  - In the new agreement, organisation who own the result could also give a non-exclusive, free and eternal licence to the group leading the work if they do not want to be a part

of the maintenance. If the organisation does not want to give such licence, we would need to see what could be done using the current PCA.
    - We would need to have veto rights for the organisations whose data are in the database in the new agreement, perhaps getting inspired by the veto rights section of the current PCA. It would be easier if the organisations check the repository continuously and veto anything they find necessary. This way every update would not need to be communicated with the organisations for their approvals.
    - It is also within this agreement where we can include matters such as participating organisations, core-team who has the rights to make decisions, how to include new information by member organisations and those who are external.
    - If creating a new agreement is not the way to go, we could also explore other solutions such as creation of an association or formation of "centres", which is usually a collaborative between industry, public sector, and universities.
    - The maintenance of the repository could also be done via CSA, and the new agreement could be prepared as part of this action.
- Ownership of the repository during the course of the project:
    - Keep in mind that it is the organisations who have signed the PCA and GA, so it is them who own the data. Exceptions could be e.g., the Swedish universities because in Sweden there is something that is called teacher exemption. This would need to be taken into account in the new agreement as the assumption is that the parties would rather want to deal with an organisation and not an individual person. Moreover, it would be easier to map the information of the repository to an organisation so that if the user has any questions, the correct contact could be made with the organisation, and not necessarily the person who provided the data.

B.4 Verification and Validation Modelling Language

Overall Benefit

- VVML is an easy-to-learn modelling tool for V&V-oriented workflows. Its usage is, though, not necessarily limited to that domain, but could be used in follow-up projects or for other application areas, e.g., industrial production or project management.
- Having a DSL, which clearly specifies which diagrams and elements can be used in the creation of a V&V method definition or its workflow, facilitates the sharing of workflow methods by providing a common standardized language.
- Linked with a method and tool-specific workflow repository, development of workflows for new use cases would be significantly simplified and accelerated.

Overall Legal Aspects

- The VVML workflows produced by its associated toolset will be published under a MIT License [268]. This license will ensure that the workflows are freely available for use and modification by anyone, subject to certain conditions.
- However, it should be noted that the source code of the toolset used to create and edit these VVML workflows remains property of LLSG. This means that the code cannot be freely

distributed or modified without LLSG's permission. Nonetheless, the published workflows will remain accessible to all interested parties who wish to use them for their own V&V purposes.

B.4.1 Workflow Modelling Tooling

Benefit

- VVML is a simple, comprehensive, and easy to use interface to model workflows and artifacts, in a compact and standardised form.

Incentive

- The VVML tools developed by LLSG are expected to be further improved and commercialised in the future. This will be achieved by developing a new Digital Transformation Modelling Language (DTML), as requested by some commercial customers. This development will enable LLSG to expand its services to a wider range of clients and provide more sophisticated solutions for their V&V needs.

Promotion

- Advertised as a KER of VALU3S. This will help to raise awareness not only of the VVML but also of VALU3S and its results among the community.

Consolidation

- It is expected that the VVML framework will be used and improved in the context of future projects, due to its flexibility and customisation.
- As more users adopt VVML in their work, we expect the community surrounding the framework to grow. This growth will provide valuable feedback that can be used to continually improve the language and its associated tools. This feedback will in turn ensure that the VVML framework remains relevant and effective in meeting the needs of the V&V community.

Legal Aspects

- The VVML Model Driven Generation (MDG) engine technology offers a powerful tool for importing and exporting UML profiles within EA. This technology provides a seamless and efficient way to transfer data between VVML and UML, enabling users to leverage the strengths of both languages.
- The VVML MDG engine technology is available for free download and is licensed under the MIT license.

B.4.2 Model Governance of a Repository of Workflows

Benefit

- Having a repository of workflows facilitates its free distribution and promotion and can increase its adoption.

Incentive

- LLSG plans to take greater control over the organization and presentation of the workflows, potentially increasing their commercial value. This could help to generate more interest in the VVML toolset and further establish it as a leading resource in the field of V&V.

Moderation

The content of the workflows will be moderated by different groups, depending on the hosting alternatives mentioned in Chapter 5:

- **LLSG owned**. A team of LLSG members will decide how to update the EA Repo.
- **Publicly available**. The LLSG team will also be the moderator, with the difference that anyone without EA will be able to see the content of the EA Repo.
- **Open to contributions**. A team that may include members outside LLSG, initially with a set of VALU3S' members, will moderate updates to the EA Repo. They will rely on typical software-engineering practices, such as fork-and-merge of git repositories.

Promotion

- The EA Repo will be advertised in social media channels already in place by VALU3S. This will help to increase visibility and awareness of the EA Repo and its benefits to potential users.

Consolidation

- The workflows in the EA Repo will be publicly available to download at LLSG's website (https://www.lieberlieber.com/), including the necessary documentation over these workflows.

Technology notes

- Updates to the VVML workflows will be performed using EA. This will ensure that the workflows are up-to-date and incorporate the latest advancements in technology.

Legal Aspects

- The ownership and hosting of the EA Repo may be transferred to Sparx Europe, also belonging to the Lieber.Group, to broaden the visibility of the workflows.
- The download of workflows will be available for free in all three alternatives listed above (LLSG owned, publicly available, and open to contributions).
- Currently all partners have licenses to use EA provided by LLSG, required to update VVML workflows. These licenses will stop being valid after the end of the project, possibly extended by a few months.

B.5 Vocabulary

Benefit

- In the context of a project, unifying terms and their definitions can provide significant benefits. This process involves establishing a common understanding of terms used throughout the project, which helps to ensure that all team members are on the same page. By doing so, project stakeholders can avoid confusion and misunderstandings that could lead to costly mistakes and delays.
- Another benefit of unifying terms is that it can help to resolve ambiguities that may arise from using different glossaries and vocabularies. Often, different standard glossaries or vocabularies may define the same term in different ways, leading to confusion among team members. By establishing a single, unambiguous meaning for these terms, project stakeholders can avoid these ambiguities and ensure that everyone is working towards the same goals.

Incentive

- Readers of project's results should clearly understand the meaning of project specific terms.
- The vocabulary should be a common place for definition of technical terms used in the project, including on the website, in the web-based repository, and in the VVML workflows.

Moderation

- Once the web-based repository is updated, for the sake of clarity, a corresponding update of the vocabulary might be necessary.
- The requirements of the vocabulary updates will initially be conducted by BUT.
- To facilitate this process, a *Technical Board* will be nominated, consisting of members of the technical committee, who will be responsible for proposing a procedure to review, maintain, and publish a new version of the vocabulary. By default, RISE will be responsible for uploading the vocabulary.
- To ensure that the process of updating the vocabulary is transparent and consistent, updates will follow similar rules to the maintenance of the project's website (Subsection 5.3.2). This includes clear documentation of changes and a review process to ensure that all updates are accurate and appropriate.

Content Quality Assurance

- The *Technical Board* should ensure that an updated term:
    - is closely related to the project and that it requires to be defined,
    - is valid, concise, and unambiguous, and
    - has a proper reference.

Presentation Quality Assurance

- The definition of terms should follow the guidelines for the vocabulary. This applies to both the PDF version and the webpage version. By adhering to the guidelines for the vocabulary, the presentation quality will be consistent, and the use of terminology will be accurate and clear.

Promotion

- The vocabulary is supplementary material and as such has no reason to be promoted.
- An updated content of web-based repository with a specific-purpose terms should be reasonably referenced to the web page of the vocabulary (using hypertext anchors). This ensures that the content remains accessible to interested parties and is easily navigable.

Consolidation

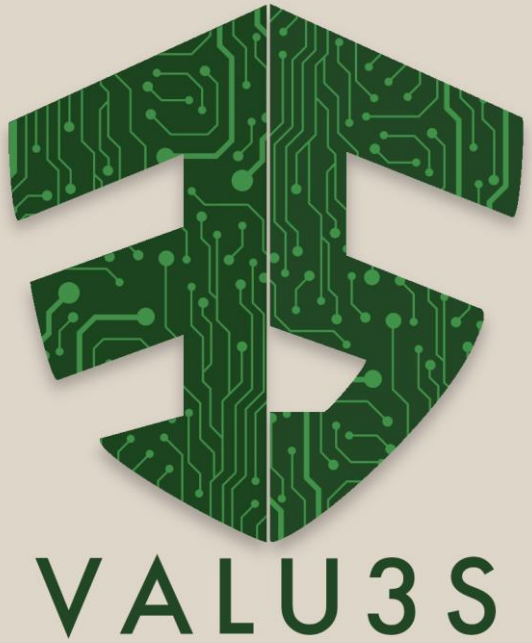
- The vocabulary is presented in a PDF version and a webpage in the web-based repository.
- Maintainers and moderators are responsible for updating the definitions of both new and existing terms, ensuring that the vocabulary remains current and relevant.

Technology notes

- Original MS Word document (docx) from which a PDF version is generated should be available to all technical committee members. This ensures that any necessary modifications or updates can be made efficiently and effectively.
- A new term in the webpage of the vocabulary should be provided with a hypertext anchor. References to the webpage of the vocabulary should use the anchors.

Legal Aspects

- The vocabulary refers to international standards and scientific resources. It contains public domain information. This ensures that the vocabulary is reliable and unbiased, making it a valuable resource for those working in the field.



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