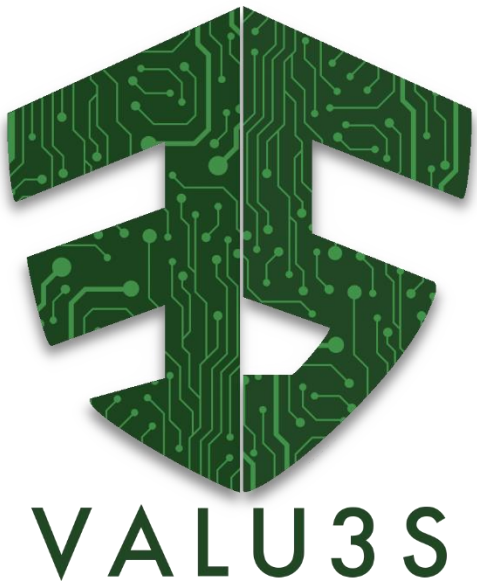

Verification and Validation of Automated Systems' Safety and Security

Interim Exploitation Activity Report and Short/Long Term Market Analysis

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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
INOVASYON MUHENDISLIK TEKNOLOJI GELISTIRME DANISMANLIK SANAYI VE TICARET LIMITED SIRKETI	IMTGD	Turkey
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 (D6.16) is the interim exploitation activity report and short/long-term market analysis of VALU3S. It identifies the main activities related to the exploitation carried out during the second year of the project and the future actions established in this field for the third year. The deliverable also examines the different target markets that the results obtained within VALU3S may reach and updates its status with respect to D6.8 [1] based on the currents situation of the coronavirus [2] and the conflict in Ukraine [3]. 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.

This deliverable also examines the commitment and responsibilities of the project partners in relation to the exploitation activities to be carried out. These are represented through specific KPIs that are continuously monitored.

The market analysis will also be updated in the final year of the project in order for the consortium to successfully identify the "smallest and most viable market" to develop an effective business plan targeted to it. Therefore, this deliverable is closely linked to other deliverable in WP6 as well as deliverables in other work packages across the project. Below are detailed those WP6 deliverables directly related to this document and when they have been or are expected to be 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).
- D6.21. Final exploitation activity report and short/long-term market analysis (Lead Participant: ALDAKIN, due: M36, Dissemination Level: Public).

The exploitation of the VALU3S results will be concretised by creating, after the end of the project, an Ecosystem of Services capable of addressing the needs of several customers from different domains. This will be accomplished via the use of tools, methodologies and competences developed within the project, through a centralised entity which will manage orders and decide which methodologies and tools have to be used according to customer specific needs and objectives. Therefore, the VALU3S ecosystem will be able to 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.

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Revision History

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0.2	2022-03-18	Íñigo Elguea (ALDAKIN)	Market Analysis (Part I)
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1.0	2022-04-27	Behrooz Sangchoolie (RISE)	Final version of the deliverable to be submitted.

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Acronyms

ADAS	Advanced Driver Assistance Systems
AI	Artificial Intelligence
CAGR	Compound Annual Growth Rate
EC	European Commission
ECG	Electrocardiogram
EU	European Union
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
IATA	International Air Transport Association
IoT	Internet of Things
IPR	Intellectual Property Rights
KER	Key Exploitable Result
KPI	Key Performance Indicators
LRT	Light Rail Transit
MRI	Magnetic Resonance Imaging
NATO	North Atlantic Treaty Organisation
OEM	Original Equipment Manufacturer
RAR	Russian Association of Robotics
RSI	Rail Supply Industry
RTO	Research Technology Organisation
SCP	Safety, Cybersecurity, and Privacy
SME	Small and Medium-Sized Enterprise
UAV	Unmanned Aerial Vehicles
US	United States
VALU3S	Verification and Validation of Automated Systems' Safety and Security
V&V	Verification and Validation

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 the internal deliverable D6.13 [4], this deliverable aims to present the activities conducted so far around the exploitation of the results, and the next steps to be taken in this regard. In addition, it also aims to gather valuable data in order 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 of the organisations that contribute 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 the stakeholders are identified.

Overall, the objectives of this deliverable are to:

- Present a report on the exploitation-related actions carried out during the second year of the project.
- Establish the objectives and exploitation-related activities to be carried out during the third year of the project.
- Introduce the relevant actors and markets in the context of exploitation and highlight the importance of analysing their role and needs.
- Ensure the entities participating in this task know their target markets so that the desired impact is achieved.
- Act as preliminary document to be updated through *D6.21 Final Exploitation Activity Report and Short/Long-Term Market Analysis* in the last year of the project.

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 both inside and outside the consortium and will therefore by publicly accessible.

This document is of special interest for all the partners of the VALU3S project, since a large number of associates have committed themselves to contribute and participate 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, in order 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 the identification of 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, this 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, as well as their current value. It also links these KPIs to the exploitation activities, thus relating the importance of market analysis in any exploitation plan. Finally, the methodology to be followed to carry out 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 will be able to identify its key exploitable result, i.e., the results with the highest exploitability.
- **Chapter 3: Initial exploitation activity report**. This chapter provides a summary of the activities conducted during the second year of the project on exploitation and lists those activities that are expected to be undertaken in general during the third and final year of the project.
- **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 analysis has been carried out on the situation caused by the still present coronavirus [2] and the current crisis in Ukraine [3] and how it has impacted the economy of each sector. A long-term analysis has also been carried out. This includes forecasts after the end of the project. 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. Partners' Specific Market Analysis and Key Exploitable Results, where the specific market analyses for each partner can be found.
- **Chapter 5: Conclusions and next steps**. The fifth and last chapter presents the conclusions obtained from this deliverable. In addition, a short analysis of the next steps is given taking into consideration the action to be taken within the exploitation and the target markets.
- **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.

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 preliminary market analysis.

2.1 Objectives and Established KPIs

This subsection identifies both the objectives to be met within the market analysis, as well as the KPIs defined to achieve successful exploitation of 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 what the current market situation is 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 precise market segment possible. An appropriate offer should be in line with the factual (but in most cases, dynamic) market situation and the subjective needs and preferences of both potential users and stakeholders. Therefore, taking all this into account, the specific objectives of this deliverable are:

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

These objectives have been established in order 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 key exploitable results of each of the entities of the consortium and thus of the project, and to establish the basis for a successful business model and marketing plan, certain specific KPIs related to the exploitation have been defined. Table 2.1 shows these KPIs, their initial expected target, the updated targets, and their current values.

The initial quantitative values were collected through a survey that was shared with the consortium partners during the first year of the project, and have been updated periodically using similar forms. 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. These values will be monitored until the end of the project and will be reported in the next deliverable (*D6.21 - Final Exploitation Activity Report and Short/Long-Term Market Analysis*). If, during this time, progress towards achieving the set target values does not appear to be achievable, appropriate measure would be adopted, and the defined target values would be re-evaluated.

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	3
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 aim at identifying possible undetected problems and correcting 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 who are 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 for the purchase of 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	3
Exp-KPI-4. Teaching and academic education activities	This KPI aims to determine the number of master theses and PhDs, as well as other types of education and training courses that can be carried out within the framework of VALU3S.	≥ 20	≥ 20	17
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	2

KPI	Description	Initial Target	Updated Target	Current Value
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	1
Exp-KPI-7. Web repository visits	Directly linked to the final outcome of the project itself, 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	NA

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 exploitation activities carried out and/or to be undertaken by the partners (see Sections 3.1.2. Consortium Exploitation Progress Monitoring and 3.2. Future Actions (3rd year)).

Table 2.2. Relation between KPIs and exploitation actions.

Actions / KPI	KPI 1	KPI 2	KPI 3	KPI 4	KPI 5	KPI 6	KPI 7
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				
A8. Consider non-technical developments (legal aspects, privacy aspects, etc.) and their influence on exploitation.		X	X				

Actions / KPI	KPI 1	KPI 2	KPI 3	KPI 4	KPI 5	KPI 6	KPI 7
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.

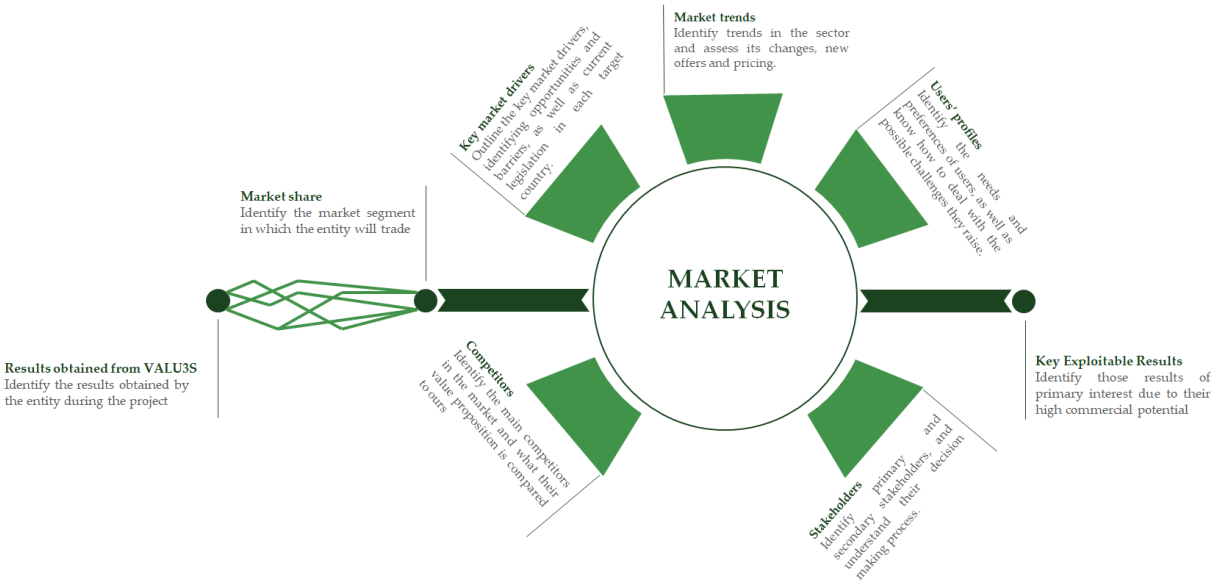


Figure 2.1. VALU3S market analysis methodology.

Firstly, some notes regarding the market analysis. Since the VALU3S project is made up of 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 vary. 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 what its specific exploitable results will be, it must determine the market share it will cover. This step is crucial, as it will determine its turnover and the market segment it will address, as well as 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 understood as 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 that the market will provide for a product to be successful, as well as the possible barriers that will have to 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 encompass the inclusion of 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 what their needs and preferences are, and identify what challenges need to be overcome in order 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 what their value proposition is 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 to understand what their decision-making process is.

Knowing what the target market is will enable each entity to determine what its key exploitable result is, and therefore, the main differentiating element of each partner with respect to its competitors.

This information has been gathered through a template in which the aforementioned data was requested. This information will be updated and further elaborated until the end of the project and reported in deliverable *D6.21 - Final Exploitation Activity Report and Short/Long Term Market Analysis*.

Chapter 3 Interim Exploitation Activity Report

This section covers the activities carried out around the exploitation during the second year and the activities planned to be undertaken in the third and final year of the project.

Below (Table 3.1 and Table 3.2) are the Lean Canvas [5] of the two key exploitable results (KERs) of VALU3S. These templates were worked on together with the Horizon Results Booster [6] in the Business Plan Development Workshop conducted by this support initiative backed by the European Commission (EC). For further information on the final exploitation plan of the project and its business plan, please refer to D6.13 [4].

To track progress on the consortium's exploitation, a short survey was shared with the partners where they identified each of the exploitation activities performed. In this sense, thanks to the market analysis made, almost all partners identified what their major individual KER will be.

3.1 Actions Carried Out So Far

Following the submission of deliverable D6.13 [4], during this second year, at the overall project level, discussions have been held around the KERs of VALU3S, which have resulted in two Lean Canvas. Meanwhile, at the individual level, each partner has focused on those exploitation activities in line with their particular business model.

3.1.1 Key Exploitable Results Lean Canvas

As indicated in deliverable D6.13 [4], the VALU3S consortium has identified two outcomes as the KERs of the project, namely the web-based repository and the V&V-centred systems engineering tool suite. Below is a short explanation of both results as well as 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.

Table 3.1. Web-based repository Lean Canvas.

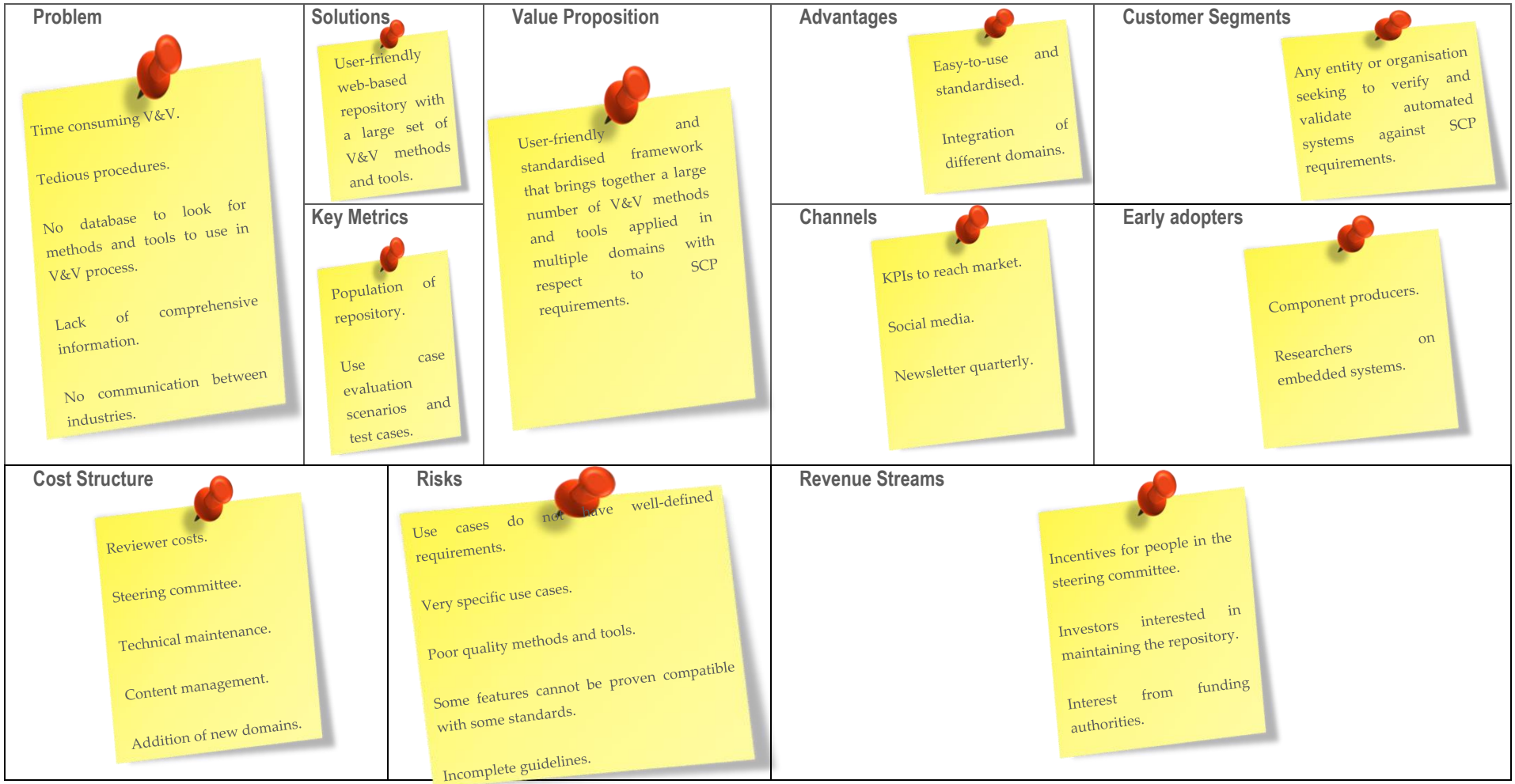
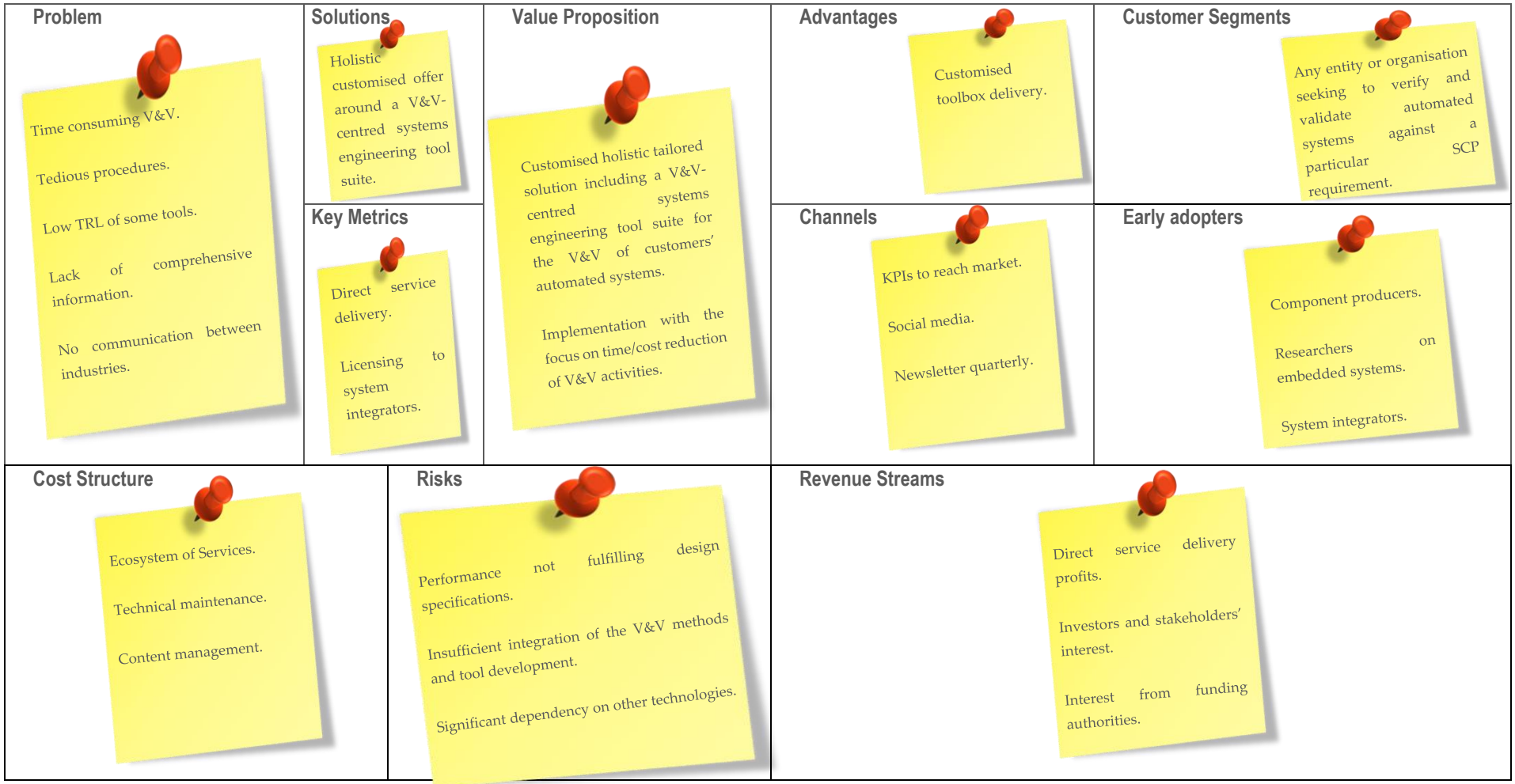


Table 3.2. V&V-centred systems engineering tool suite Lean Canvas.



3.1.2 Consortium Exploitation Progress Monitoring

During the second year of the project, the developments to be carried out have reached a sufficiently high level of maturity that many partners have started to work extensively on exploitation-related activities. Figure 3.1 shows the results of the survey shared with partners on exploitation activities. For an insight into the *x*-axis, please see the list of exploitation activities in Section 2.2. Mapping between Market Analysis and Exploitation Plan. Although the percentages of activities are spread out, five main activities stand out:

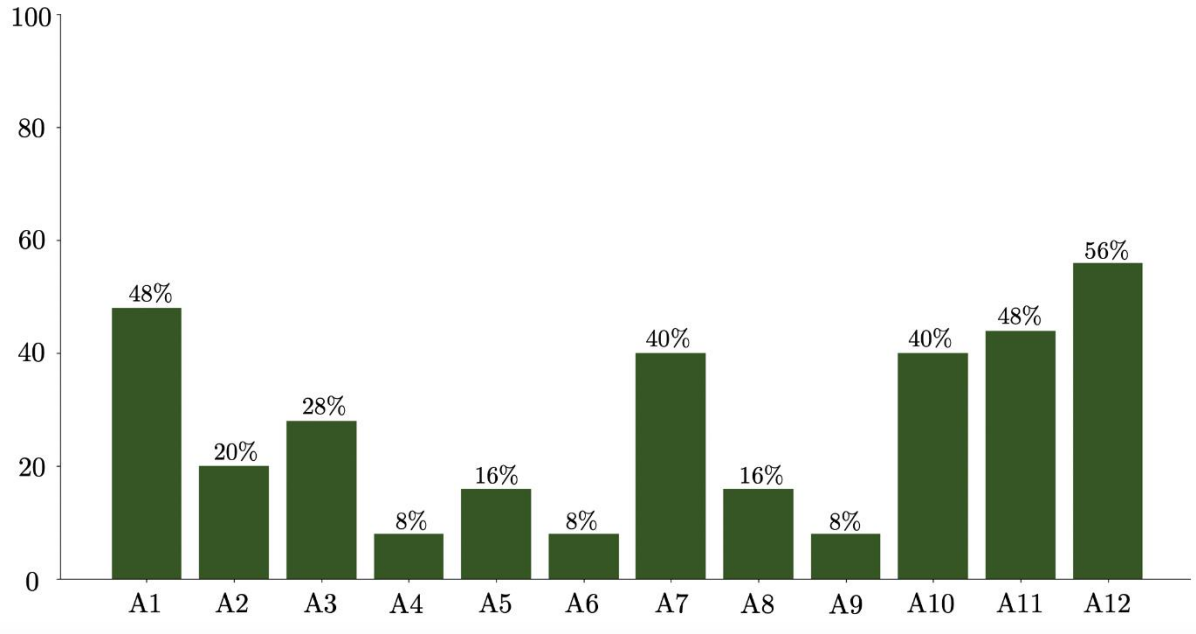


Figure 3.1. Percentage share of VALU3S partners in exploitation activities during the second year.

1. **A1. Focus on the main results and their commercial viability**. Thanks to the market analysis, 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 [7], 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, each VALU3S entity has identified its own KER. These results can be found in Appendix A. Partners' Specific Market Analysis and Key Exploitable Results.
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. However, the KPIs related to this activity, such as *Exp-KPI-2. Beta testing agreements* and *Exp-KPI-3. (Potential) agreements with early customers or stakeholders*, are still far from the established values and further dedication to this activity is expected in the coming months.

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**. The A10 activity ("Offer seminars, lectures, courses, and the-like with topics related to the project") 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.

3.2 Future Actions (3rd year)

For the third and final year of the project, a greater commitment to exploitation activities is expected from all project partners. So far, it seems that the main exploitation of the results has been focused on those activities related with teaching. This is logical given that many universities and even RTOs did not expect to exploit tangible developments, but rather the *know-how* acquired, resulting in courses for students and/or a knowledge exchange with companies in the industry.

However, as the project continues and the level of maturity of some results increases, it is expected that many partners will intensify their exploitation activities, which in turn will create new business opportunities before the end of the project. In fact, the current values of *Exp-KPI-2. Beta testing agreements* and *Exp-KPI-3. (Potential) agreements with early customers or stakeholders* are still far from those established, so a significant effort is expected to be made in those relationships with customers and stakeholders that enhance the exploitation of the results and generation of profits for the partners.

To this end, partners will be periodically reminded of the importance of both KPIs for the exploitation of VALU3S and for their own individual exploitation. Beta testing is a tool that assesses customer satisfaction and provides them with an early insight into releases, which in turn can lead to early commercial agreements. It also allows the customer to helping shape the product, providing highly valuable feedback to the producer.

An exploitation activity that has been hardly addressed by the consortium partners and that could help in the achievement of these KPIs could be activity *A6. Involve marketing, product-management, and sales departments early in the exploitation process*. Although this activity is mainly linked to *Exp-KPI-5. Traders recruited*, the knowledge of the marketing department or of a trader in the dissemination of a company's results can play a key role in the attainment of testing agreements, or even commercial agreements.

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] and the Ukraine crisis [3]. This analysis has been conducted in terms of 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[1].
- European Market of Non-EU Member Countries and Neighbouring Partner Countries[2].
- Russia and Asia.
- Latin America.

However, the document should be considered preliminary, as it reflects the partners' plans at the current stage of the project (M24). A final version will be published in the third year (M36) of the project.

4.1 Automotive Domain

4.1.1 Short-term Market Analysis

In 2020, the impact of the pandemic caused by the coronavirus [2] was more than noticeable, with global automotive production down by an estimated 13% [8], and the number of cars sold by 15.3% [9]. However, the recovery of this market started to materialise towards the end of the year, although shortages of semiconductors hindered the expected growth [10]. With microchip supply expected to stabilise in 2022, predictions for this year's automotive sales are optimistic. According to Euromonitor [11], unit sales volumes in 2022 are projected to be around 78 million units (+10% compared to 2021, which in turn is 10% higher than in 2020), surpassing the pre-pandemic levels of 2019. In contrast, the European Automobile Manufacturers Association (ACEA) also forecasts an increase in sales this year, although in this case much more moderate, predicting a final estimate almost 20% below the pre-crisis sales levels of 2019 [12]. However, these reports do not reflect the recent crisis in Ukraine [3], which has increased the price of fuel in many Eurozone countries, as can be seen in Figure 4.1, and which is likely to reduce demand for automobiles for some time to come [13], [14].

[1] Please note that although Switzerland is outside the European Union, it participated for the most part in the European Single Market.

[2] At this stage, the analysis of the European Market of Non-EU Member Countries and Neighbouring Partner Countries comprises Turkey, Israel, Serbia, and Croatia.

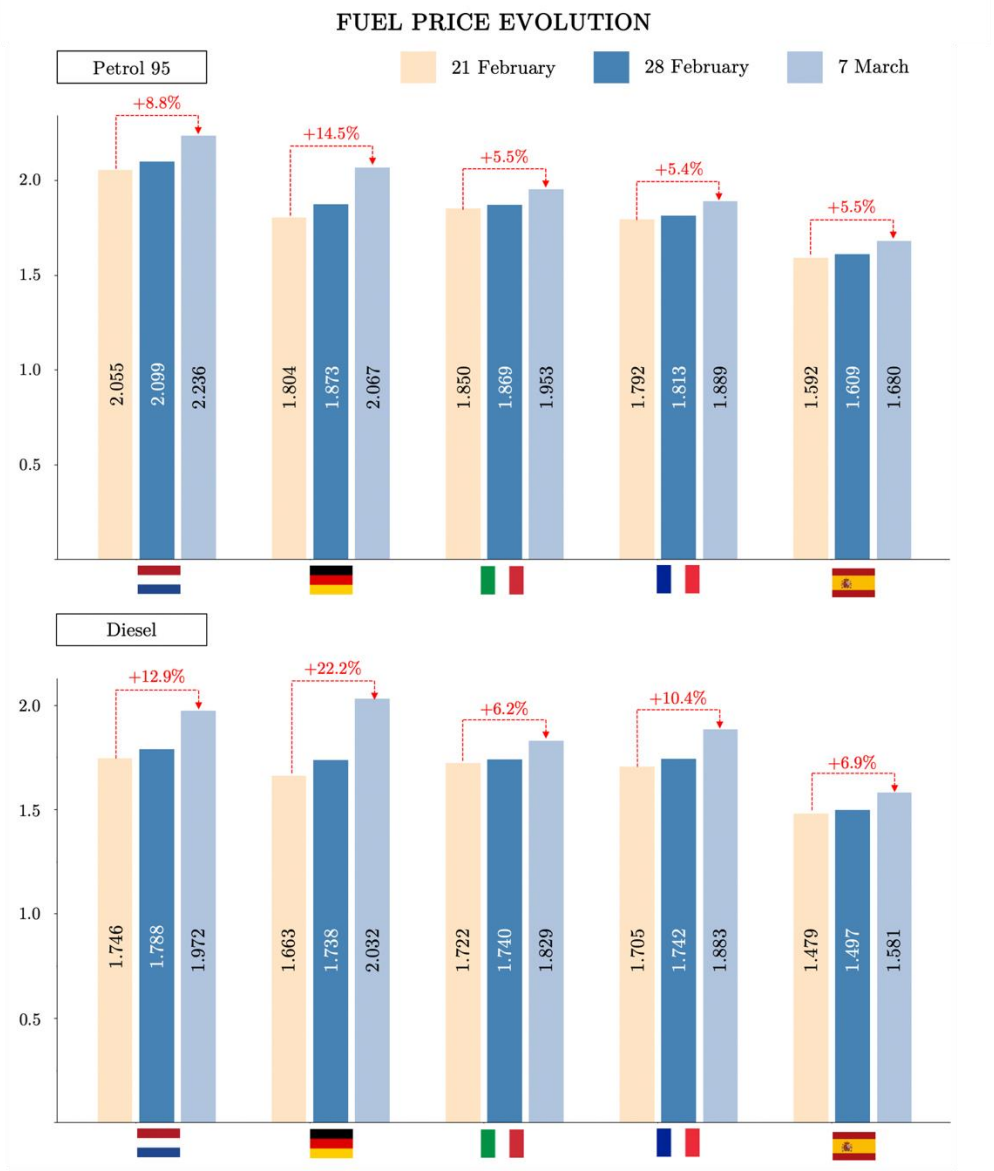


Figure 4.1. Fuel price evolution in different Eurozone countries [15].

Against a backdrop of a shrinking vehicle market hampered by supply chain problems, electric vehicles have sharply increased their market share, growing more than 10-fold between 2017 and 2021, selling around 6.4 million units last year. The most significant case is Tesla, being the fastest growing car brand among all brands over the course of the pandemic, with brand value growth of 271% in the last two year, according to the latest Brand Finance report [16]. However, looking at the bigger picture, all electric vehicles are expected to continue to trend upwards, although access to microchips is expected to continue to hamper their manufacture for a period of time.

4.1.2 Long-term Market Analysis

Amid the coronavirus outbreak [2], Oxford Economics forecast 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 [8]. One year later, according to an analysis of the global automotive industry, it will take about 10 years for the European automotive market to reach the size

of 2019. In contrast, the industry in countries such as China has not been affected as much, becoming even the first market with a production rate of 48.9 cars per minute in this final stretch of the pandemic, compared to 20.7 cars per minute in the United States or 8.9 in Germany [17]. The main challenge for the coming years will therefore be to rebuild production, although this objective may be compromised by other triggers.

One of these will be the crisis in Ukraine [3], the consequences of which are not yet known in this market. According to Colin Langan, an automotive analyst at Wells Fargo [18], 155 of the European car production could be at risk due to the closures of cable factories in Ukraine resulting from the Russian invasion. In addition, many car brands have closed their plants in Russia and European Union (EU) is discussing a ban on exports of luxury cars over 50.000€ to the country [19].

Regarding the V&V market, these impacts on automotive are also expected to negatively affect turnover. However, V&V is projected to account for ~29% (USD 24 billion) of the total automotive software market by 2030 [20].

The updated expectations for this domain for the four markets covered by VALU3S, once the project is completed, are analysed below. The individual market analyses of 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. 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 [21]. The sector also represents the largest private investor in research and development, making the European Union 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 compound annual growth rate (CAGR) of about 9.7% by 2025 [22].

Milestones on the road to this future state include primarily 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 [23]. These milestones will be driven in part 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 original equipment manufacturers (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 a large majority of the models available in Europe [24].

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 Japanese manufacturers that invested in production facilities to meet domestic demand while exporting to Europe [25]. Despite the surprising growth of the Turkish car market during the first two quarters of last year, where according to data from the Automobile Manufacturers Association, sales registered an increase of close to 60% and 51%, respectively, a double-digit fall was reported in the second part of the year. This resulted in finally closing 2021 with sales 4.4% below the previous year [26]. However, the latest reports point to the fact that the car manufacturing market in Turkey is 15.5%, with an estimated value of USD 34.5 billion by 2025 [27].

Conversely, the impact of the pandemic in Israel was even greater than in Turkey, significantly affecting sale, which fell by 15% compared to 2019 [28]. Also, unlike the early predictions made by some reports last year about the growth of the Israeli car market in coming years and despite its remarkable growth this year, the latest statistics from Statista are not encouraging and predict a CAGR of -1.07% in the passenger car market until 2026 [29]. However, this does not detract from the fact that the Israeli smart mobility market is expected to grow by 21.2% over the next 5 years. This is because leading Israeli companies and start-ups are mainly operating 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 during the forecast period. Specifically, already in 2016, the government invested USD 70.9 million for research and deployment smart mobility technologies across the country, with a particular focus on developing vehicle safety systems commonly known as advanced driver assistance systems (ADAS) [30].

For the Balkan countries surveyed, namely, Serbia and Croatia, the car market is expected to continue 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 [31] and, given that this industry is certainly the most important industrial today in the country, an increase in foreign investments is also expected [32]. Croatia, meanwhile, reported an even greater increase last year, with a 25.5% increase in sales [33], [34]. Also, according to Statista data from the end of last year, the country's automotive market is projected to reach a value of USD 79.33 million by 2025 [35].

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 slowing economic growth, lower oil prices and the devaluation of the Russian rouble, all of which affected the consumer spending [36].

Two years ago, at the height of the pandemic lockdown, the closure of several Chinese 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 [37].

Now, with the even stronger devaluation of the rouble following Western economic sanctions, the Russian car market could be further affected in the already constrained global automotive supply chain. At the moment, major car brands have already shut down plants in Moscow and St. Petersburg [38], and it is expected that new car sales in Russia could fall by as much as 50% by 2022 [39]. However, at this stage, it is difficult to predict quantitatively how this conflict will affect the Russian car market in

the years to come, although some analysts already predict that it will affect the entire European continent and have cut their forecast for light vehicle sale in Europe by 2 million units per year in the period 2022-2024 [40].

In Asia, in turn, key markets such as China, South Korea, Japan and Taiwan have 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 [41].

Asia-Pacific is now estimated to be the largest automotive market by 2025 due to the growing demand for passenger cars and fuel-efficient vehicles over the years. 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 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 [42].

This initiative 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 [43]. In addition, countries such as Thailand, aims 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 [44].

Latin America

The Latin American passenger car market is steadily recovering after most countries were strongly affected by the inflation, the economic crisis and 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 at a very high rate [45]. 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 4.61% CAGR by 2027 [46]. In fact, in Brazil, with 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.

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% over the period. 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 the need to address future energy requirements have led OEMs to start producing electric vehicles in the region [47].

4.2 Agriculture Domain

4.2.1 Short-term Market Analysis

The last two years, the spread of coronavirus mainly affected the agricultural market both in terms of food supply and demand [48]. 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 [49]. However, according to [50], from 2022 onwards, prices were expected to recover gradually, but to remain below baseline levels for some time.

Notwithstanding, the recent humanitarian crisis in Ukraine [3] has put the recovery of the agricultural market in jeopardy. This is because both Russia and Ukraine are among the most important producers of agricultural products in the world. 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. Consequently, this concentration could expose these markets to greater vulnerability to crisis and volatility [51].

In Ukraine, the recent intensified conflict has already 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 could take their toll on the country's cereal and vegetable oil exports in the coming months. Food and Agriculture Organisation (FAO) also suggests that, as a result of the conflict, between 20 and 30% of the areas planted with winter cereals, maize and sunflower seeds in Ukraine will not be planted or will remain unharvested during the 2022/23 season. There is also much uncertainty surrounding Russia's export prospects in the future, given the sales difficulties that may arise as a result of the economic sanctions imposed on the country. All this could mean a resulting global supply shortfall that could push up food and feed prices by 8-22% [51].

4.2.2 Long-term Market Analysis

Despite the impact of 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 gross domestic product (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 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% per year, mainly in emerging economies and low-income countries. This will be triggered by wider access to inputs, as well as investments in technology, infrastructure, and agricultural training to improve productivity, are key drivers of agricultural development [52].

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 [52].

This yield improvement, in turn, is directly related to the digitisation of equipment and the major trends being witnessed in the global agricultural testing and device V&V market, which is expected to grow at a CAGR proportional to the agricultural market [53].

The expectations for this domain for the four markets covered by VALU3S, once the project is completed, 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) [54]. 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. But the latest report, released in December 2021, makes a slightly different prediction. This, in turn, may be further conditioned by the crisis in Ukraine [3], given that this country 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. Russia's countersanctions may also target the agricultural sector, as (depending on the member state in question) trade relations with Russia may have been important [55].

Without considering such an eventuality, the EC's systemic uncertainty analysis [56] predicts that the total agricultural area in the EU will decrease slightly, mainly due to a reduction in the area of arable crops between 2021 and 2031. Specifically, the total EU cereal area is projected to decrease to 51.2 million hectares, driven by a decrease in the main cereal areas. Wheat and barley yields are expected to decline modestly, while maize yields could continue to increase due to yield improvements in eastern EU countries.

On the trade side, the EU will remain competitive, but will face strong competition from other key players, especially from the Black Sea region, leading to a reduction in market shares, in a growing market.

The EU oilseed area will be 10.7 million hectares, similar to current levels. Oilseed yields are expected to increase slowly, especially sunflower and soybean. Strong growth in protein crop production will also be driven by increased area and improved yields, while the EU sugar area will stabilise in the medium term and EU production will slowly increase to 16.3 million tonnes in 2031. Furthermore, demand for feed from arable crops is expected to decrease due to declining pig, cattle, and dairy herds. Increased organic dairy production and further extensification and diversification will increase the share of grass protein in the feed ration. Feed prices will decrease over the next two years and then revalue until 2031.

Europe's intelligent agriculture market, highly linked to yield improvement and involving technology-driven information analysis of data acquired from the fields and the application of inputs according to the data analysis for raising crop productivity, is also estimated to grow at a CAGR of 13.42% and to reach USD 2.71 billion by 2026 [57].

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 [58]. However, due to the coronavirus outbreak, according to the Turkish Statistical Institute [59], Turkey's agricultural GDP declined around 50% between the third and fourth quarter of last year. Notwithstanding, according to Trading Economics [60], the market is expected to recover and by 2023, GDP is expected to grow over 60%.

This could take longer depending on the still to be analysed repercussions of the conflict in Ukraine [3] on the Turkish economy. Turkey's annual trade volume is USD 34.7 billion with Russia, and USD 7.4 billion with Ukraine, according to figures from the Turkish Statistical Institute. 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 [61].

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 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 year ago [61].

As regards Israel, its agriculture is exceptionally unique, as land and water resources are mostly state-owned and agricultural production is controlled by cooperative communities. Its production peaked in 2018, with the production of oilseeds, pulses, fruits and vegetables, cereals and grains, cash crops, and roots and tubers. However, despite the crisis caused by the coronavirus, a year ago, the country was expected to record a CAGR of 5.50% in the coming years [62]. This would be underpinned by an increase in technological progress and innovation, the high level of investment in research and development, and the possible expansion of water resources.

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]. Based on these, predictions for the development of the agricultural sector in Israel may be slightly affected and not meet the expectations that were set a year ago.

In turn, Serbia and Croatia have recently declared that they have large reserves of wheat, corn, flour, and cooking oil, so the agricultural market will not be affected. In fact, they will supply neighbouring countries such as Bosnia and Herzegovina and Montenegro with these cereals [64]–[66].

Russia and Asia

The agriculture market was and remains one of the most stable in Russia. Among the country's most important crops are sunflower oil, cereals, and corn [67]. Moreover, in recent years it had become a major player in international wheat markets, even surpassing the EU in exports.

However, with the sanction packages imposed by the West on Russia, it seems to have made buyers of agricultural products reluctant to commit to Russian supplies. In addition, banks are less willing to finance Russian commodity trade, which will further weigh on Russian supply on the world market.

However, even if a short-term demand shock is seen for Russian grain, it may not be sustainable, as major consuming nations will become increasingly concerned about food inflation and the potential unrest this could cause.

The latest government data available shows Russia exported 25.2 million tonnes of wheat in the 2021/22 season until 17 February, leaving around 28% of the crop still to be exported this season, assuming an export number of 35 million for the full season. Russian shipments since the war are holding up better than Ukrainian shipments, however, due to sanctioning, the pace is likely to have slowed [68].

Looking ahead, if Russian commodities continue to be sanctioned, we could start to see farmers react by reducing acreage. This could be reflected in spring wheat and maize where there is a possibility that the current uncertainty could lead to a reduction in plantings [68].

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 [69]. Its contribution in 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 the agricultural market in this country is expected to grow at a CAGR of 6.8% by 2025 [70]. Likewise, the Southeast Asian seed market is expected to register a CAGR of 6.4% by 2025 [71]. Conversely, declining maize stocks in China could create opportunities to diversify production into other commodities in this country.

As in other regions, the area under cultivation will shrink, so production increases will be driven by productivity improvements. By 2025, the Asia Pacific smart agriculture market is forecast to rise at an influential rate. Currently, China held 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 [72].

Latin America

Before the pandemic, the agricultural sector showed a clear upward trend in the coming years on the Latin American continent. However, this increase, as in the rest of the world, 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 [73].

Nevertheless, the productive growth of the sector will continue, where the improvement will be mainly in productivity, rather than in the expansion of arable land. Hence, demand will be determined by population growth, the income of each region and its main markets [74].

Regarding oilseeds, soybean production has increased considerably in recent years, mainly in Argentina, Brazil and Paraguay, where the expansion of land for cultivation has been remarkable. This production will continue to grow in the next decade, with more land being allocated to soybean cultivation [74].

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 [74].

For tubers, production has grown relatively slowly in the region. While in Brazil, production has been declining, in several Central American countries and in Peru, production has been increasing and is expected to continue to grow over the next decade [74].

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 [74].

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 conflict 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 [75].

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 [76].

4.3 Railway Domain

4.3.1 Short-term Market Analysis

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 that many countries are giving to the railway sector through investments in rolling stock, railway control and infrastructure. This growth and the investment made in this area is 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 [77].

Indeed, many of the 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 [78].

Now, with the conflict in Ukraine [3], these routes have become inaccessible, leaving many operators looking for alternative routes, at a time when the container shipping industry remains beset by port congestion, shipping delays and container shortages, resulting in long delays and record freight rates [78]. In fact, network equipment manufacturers such as, Zyxel Communications Corp, have stopped shipping from China to Europe by rail, and this is currently hampering China's Belt and Road Initiative [79].

4.3.2 Long-term Market Analysis

Despite the negative impact that coronavirus had on the sector mainly during 2020, the sector has been able to recover and is expected to grow at CAGR of over 10% between the end of last year and 2026 [80]. In this sense, the rail freight market is expected to be one of the slowest growing markets with an increase of slightly more than 2% over the forecast timeframe [81]. In contrast, the autonomous train market will have a higher importance and is expected to reach USD 10.22 billion by 2026 registering a CAGR of 5.61% during the forecast period [82].

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 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 at a nascent stage, the need for large investments in equipment R&D is expected to restrain market growth [82].

Growth is also expected in the global rail flaw detection market, which is projected to grow at a CAGR of 7.10% between 2021 and 2030 [83], in the railway automated inspection equipment market [84], or in the global rail testing vehicle market [85].

The expectations for this domain for the four markets covered by VALU3S, once the project is completed, 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 [86], the European rail market is expected to reach a value of €53.98 billion by 2023. Although the war in Ukraine could push Asia-Europe rail cargo back to sea and increase the growing queues of ships in ports [87], both the European rail freight market and rail passenger transport itself are expected to see stable growth over the next few years [88], [89]. This will be due to several key factors such as increasing urbanisation, increasing 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 [90].

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 [91], 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 as a whole, including operators and infrastructure, accounts for more than one million direct and 1.2 million indirect jobs in the EU. However, this is still far less than the 13.8 million jobs provided by the automotive sector previously mentioned [21]. On the other hand, European RSI invests 2.7% of its annual turnover in R&D and represents 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, enabling the creation of benefits such as mass customisation, increased production speed, better quality and higher productivity. This strategic goal will be reflected in 2030, where the EU will strengthen its position as a world leader in the development of high-tech products and solutions [92], [93].

Finally, it is important to mention the main players operating in the connected rail market in Europe, which are Bombardier, Bosch, Siemens AG, IBM Corporation and Atos Corporation.

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

In Turkey, the transport and logistics market are expected to grow at a steady rate of around 8% in the coming years [54]. This continued high growth is justified by the country's strategic location between Asia and Europe. In fact, Turkey has become an alternative route for the transport of rail cargo between the two continents as countries such as Ukraine, Russia and Belarus have closed down [94].

In addition, the government intends to build another 5.500 km of high-speed and fast rail lines by the end of next year [95]. 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 qualification of personnel 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 for the development of advanced railway industry and the creation of a

domestic and national railway industry [96]. In the past, specifically before 2003, Turkey was dependent 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 [95].

In Israel, there is a growing trend towards the use of public transport, such as trains and metros. Israel's population is expected to grow by about 5 million over the next 23 years, 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 in the development of 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 [97], [98].

Meanwhile, in 2020, the Serbian government planned to invest €3.5 billion in the modernisation of the railway infrastructure as part of the Serbia 2025 programme [99]. 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 [100].

When the reconstruction is completed, the speed of the line 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 per cent 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) [101].

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 [102].

Russia and Asia

The Russian railway system, one of the largest in the world, is of strategic importance for the Russian economy. The railway sector in Russia is undergoing a major development with several projects planned. As a result, Russia is expected to invest approximately USD 84 billion in railway projects by 2026 [103]. The two main strategic lines driving the Russian rail sector are freight transport, which is currently severely hampered by the conflict with Ukraine [3], and passenger transport through the creation of high-speed trains.

In the event that the sanctions imposed by the West do not last and/or do not affect freight transport, Russia's current rail infrastructure and network does not have sufficient capacity and capability to handle the growing traffic and increasing freight volumes expected in the next decade. Therefore,

Russia plans to develop new transport corridors to experience a steady flow of goods in and out of the country. There are two strategic areas of interest for Russian freight transport: the Arctic and the Far East. In fact, the Arctic is a logistic development hotspot, with an expenditure of approximately USD 136 billion to ensure year-round Arctic transport by 2030 [104].

In addition, 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 see a significant increase in demand across the region [105].

In railway, Asia-Pacific is the fastest growing region globally and is expected to be the industry leader in the coming years, progressing at a CAGR of 2.87% between 2021 and 2025. This will be mainly driven by increased investments in the market, the low cost of rail freight services and the increase in cross-border industrial and commercial activities, although the latter is currently severely affected by the conflict between Russia and Ukraine hindering trade between Asia and Europe [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 [91]. 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 [107].

India is also one of the largest and fastest growing markets for railway components after China. India is expected to be the fastest growing country in the coming years. This growth is justified by the significant investments it has made 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% [105]. 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) [108].

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 [108].

Latin America

One of the regions that will experience significant growth in the rail sector is Latin America. The Latin American freight transport and logistics market is growing strongly over the period 2020-2026, where it is expected to register a CAGR of 10.74% over the forecast period [109]. Within the sector, the Latin American rail components and infrastructure market will generate around USD 7 billion by 2026 [110]. 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, which is driving the market growth exponentially [111].

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 [112].

4.4 Healthcare Domain

4.4.1 Short-term Market Analysis

The impact of coronavirus on the healthcare market was enormous and severely disrupted the entire supply chain of the healthcare chain, from raw materials to manufacturing and delivery [113]. In fact, many medical companies had to double their production capacity due to the high demand [114] and even strategic partnerships between healthcare and industry were formed in order to cope with such demand [115].

Today, the global health sector continues to face the new challenges posed by the pandemic, much more under control, but which continues to dominate the attention and resources of health systems. Indeed, these health systems continue to elevate the human experience of their staff and reshape what, how and where work is done, rapidly expanding virtual health services for patients, and forging partnerships to produce and procure the necessary vaccines, treatments, and supplies. In fact, the digitisation of healthcare and modernisation of the hospital system is a major concern in many countries, where the pandemic highlighted the importance of digital and centralised management. Therefore, a large outlay is expected from several countries in order to bridge this digital gap [116].

Nevertheless, this should not be a big challenge, given that the healthcare market takes more than 10% of the GDP of most developed countries, with North America and Europe being the continents with the highest revenues [117].

4.4.2 Long-term Market Analysis

According to Verified Market Research [118], 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 that are 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 [119].

This change will require the transformation of 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 around the

world 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.

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, the costs of mental illness are expected to cause USD 6 trillion per year worldwide [116].

As for the medical device testing market, due to the increasing reliance to be placed on automated medical equipment, the market is expected to reach USD 16.0 billion by 2027, exhibiting at a CAGR of 6.7% during 2022-2027 [120].

The expectations for this domain for the four markets covered by VALU3S, once the project is completed, 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 industry is expected to grow considerably between 2022 and 2027. This is reflected in four of the most important markets in the domain, such as the medical devices market, healthcare analytics market, home healthcare market and digital health market, which is expected to grow at a CAGR of 5.8%, 19%, 8.66% and 27.1%, respectively over the forecast period. 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 [121]–[124].

Indeed, while recent government regulations and the authorisation of emergency kits are driving the growth of the medical device industry [121], the use of information and communication technology in medicine is also gaining momentum with mobile applications being widely used to improve health and lifestyle [124].

With the advent of digital devices such as Internet of Things (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 [122].

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 a high level protection of safety

of patients and users, high quality medical devices on the market, and a transparent, robust and sustainable medical devices market [125].

In addition, the country has a number of strategic objectives that will significantly boost 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 [126]. In addition, Turkish companies such as MLP Care have partnered with US companies to develop AI-based clinical solutions [127]. Given the benefits that have been 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 Israel healthcare industry continues to strengthen and grow year by year [128]. The increase in the number of companies, together with the maturity levels of the industry and the rise of innovation in new and developing sectors, are the factors that are contributing to the success of the healthcare industry and the important role it plays in the Israeli economy.

Israel'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 a multitude of strengths and substantial capabilities to occupy a leading position in the healthcare market, with high economic value and a potential to become an additional growth engine for Israel's economy [128].

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 [129]. In particular, within healthcare, there is a clear trend towards the design and development of medical devices, as, the number of companies involved in this sector has increased substantially since 2018. Also, the healthcare IT sector is becoming much more important, with innovative solutions in this field [130].

Another of Israel's strengths is the cooperation it is having with Australia in relation to 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, with a focus on solutions in medicine and cybersecurity, giving the two countries a competitive advantage [129].

In Serbia, driven mainly by increasing market conditions and technological advances, healthcare market revenues are expected to almost double between 2022 and 2025, from USD 33 million and USD 61 million [131]. In particular, the medical equipment market will experience the strongest growth in terms of sales. In terms of investment opportunities and product sales, the sector will offer strong growth prospects for domestic and international companies [132].

In Croatia, the medical devices market has registered a significant recovery in 2021 and 2022. This will be followed by a period of single-digit growth in both local currency and USD terms during the period 2023-2026. Growth in USD terms will be stronger due to the depreciation of the local currency, especially over the next two years, as the government targets the adoption of the euro by January 2023. During the forecast period, the market will remain dependent on imports due to the absence of large equipment manufacturers [133].

Russia and Asia

Overall, the Russian healthcare market is not expected to grow as strongly as in other regions. For example, based on [134], the Russian medical devices market is expected to register a low single-digit CAGR by 2025. This small growth will be mainly supported by sales of diagnostic imaging systems, dental products, and orthopaedics and prosthetics.

As for the healthcare analytics market, the entry of new key players in Russia could increase market demand. In addition, the adoption of AI on various platforms to provide high-quality treatment services will drive the market growth rate [122]. Due to aging population, increasing incidences of chronic diseases, growing demand for affordable healthcare delivery systems, Russia home healthcare market could be the fastest growing market in the forecast period. In this case, the market is projected to reach USD 134.8 billion in 2026, exhibiting a CAGR of 8.66% by that year [135].

Russia is also currently investing in the development of several applications and projects for the healthcare sector. These include "SMSmame", an innovative educational service for pregnant women and young mothers, "Life Button", an application with a medical-social panic button for the elderly, adults and children with disabilities, or the "Alive Heart and Activity Monitor" system, developed by Alive Technologies (Australia) in cooperation with Moscow State University, for the diagnosis and monitoring of chronic heart diseases [136].

In contrast, Asia Pacific is likely to be the fastest growing region by 2027 in the entire healthcare domain. Growing medical device industry and increasing demand for imaging and diagnostic equipment are expected to bolster the growth of the Asia Pacific medical devices market which is expected to reach a value of USD 82 billion growing at a CAGR of 7.4% [137]. This growth will also be notable in Southeast Asia, where increasing demand for accurate and early diagnostic methodologies will boost the market [138].

The healthcare analytics market will have high growth, expected to reach USD 5.2 billion by 2026 after growing at a CAGR of 19.7%. China and India will lead this market due to the use of IT solutions. While China already holds a large share of this market, India is expected to register remarkable growth [139]. 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% [140].

Finally, the digital health market will be the fastest growing market, with a forecast CAGR of 29.2%. 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 [141].

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 6% between now and 2027, with the market reaching USD 87 million. This growth will be driven by the high demand being generated 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 [142].

The healthcare analytics market is expected to have the highest growth, reaching almost 20% CAGR between this year and 2027 [143]. 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 [144].

Lastly, the digital health market is expected to progress in a healthy way 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 [145].

4.5 Aerospace Domain

4.5.1 Short-term Market Analysis

The aerospace industry was probably the sector most affected by the pandemic [146], posing a significant challenge to revenues, earnings before interest and taxes, and cash flow for aerospace manufacturers and suppliers [147]. 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 on 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 [148].

Now, in 2022, trends in commercial air travel and customer order activity are positive, although macroeconomic trends suggest that demand for small and medium-sized aircraft will continue to recover throughout this year. However, with air travel volumes already well off the lows seen in 2020, aftermarket revenues could recover strongly in 2022 as air traffic recovers.

However, this boom could be partially affected by the recent crisis in Ukraine [3]. Already, multiple foreign airlines have stopped operating and maintaining their fleet in Russia, but its effect could spill over to the rest of the world given the rising oil prices and longer routes needed to bypass airspace over Russia, which is expected to push up ticket prices and air freight rates, which in turn could dampen demand in the industry [149].

4.5.2 Long-term Market Analysis

Following the crisis in the aerospace sector in 2020, passenger traffic plummeted dramatically, and reports from that year predicted that it would take 2-3 years for the sector to fully recover [150]. Now, this market is expected to almost double in the next ten years. From a growth in 2020 at CAGR of -0.3% since 2015, where the market was valued at USD 298.0 billion, by 2025 it is expected to grow at a CAGR of 7.7% reaching USD 430.9 billion and then slow down its growth to a CAGR of 5.9% until 2030, reaching USD 573.6 billion [151].

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 the advancement of technology and innovation, the use of different manufacturing materials, and the decrease in 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 [152]. One example is GE Aviation, which is using machine learning and data analytics to identify engine failures, increasing component life, and reducing maintenance costs. Boeing, meanwhile, has successfully created machine learning algorithms to design aircraft and automate factory operations.

The aerospace testing market will also grow over the next few years. However, its growth will be lower than initially forecast [153], where it is currently expected to grow at a CAGR of 0.7% by 2025 [154]. The main drivers for this market will be the increase in aircraft deliveries, the adoption of new materials in aircraft, and stringent aviation and certification regulations for aircraft safety.

The expectations for this domain for the four markets covered by VALU3S, once the project is completed, 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 A.4.5, respectively.

European Single Market

According to the latest Research and Markets report [155], the European aerospace market is expected to grow at a CAGR of 0.8% by 2025. However, this report was launched at the end of last year, so it did not consider the recent Ukraine crisis [3]. The closure of Ukrainian airspace and the unavailability of Russian airspace to most airlines has led to a surge in cancelled or diverted long flights (see Figure 4.2) which, coupled with rising oil prices, is beginning to hit airlines' profitability hard, dashing optimism that European aviation would recover this year to near pre-pandemic levels [156]. As a result, forecasts made in the last year may be slightly affected as a consequence of this conflict.

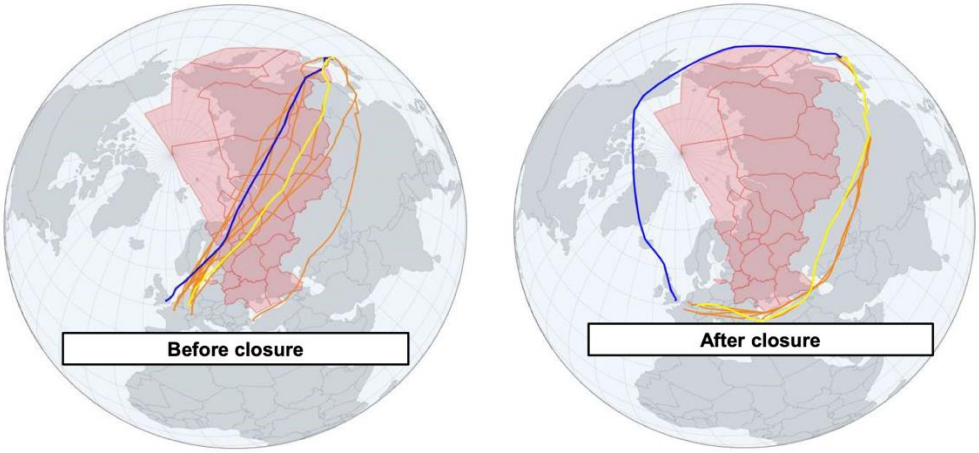


Figure 4.2. Diversion of international flights due to the closure of Ukrainian and Russian airspace as a result of the Ukrainian conflict [157].

Nevertheless, 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 [158]. 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 [159]. 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 reducing 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 [160], a public-private partnership between the European Commission 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% between this year and 2027. This growth will be driven, on the one hand, 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 in the coming year where, currently, the Middle East and the Commonwealth of Independent States are two major importers of Turkish aerospace parts [161].

Moreover, leveraging the role of Turkish drones in bolstering Ukraine's defence in the conflict between Ukraine and Russia, Turkey's president has urged North Atlantic Treaty Organisation (NATO) partners to lift restrictions on the country's military sales. 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 would regain the possibility to export aerial military weaponry. However, while European countries are likely to be more flexible, US sanctions remain a tough row to hoe [162].

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 [163]. To achieve these goals, the Turkish government proposes to restructure its defence export incentive system. 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 the production of 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 [164].

Despite the remarkable impact of the pandemic on the industry in the country, the latest Research and Markets report predicted last year that the Israeli aerospace and defence industry would grow at a CAGR of 6.5% by 2025 [165]. However, the war between Russia and Ukraine has caused Germany, for example, to double its defence budget and other European countries to rush to buy arms, which in turn has caused the shares of several Israeli aerospace arms companies to soar. For instance, Elbit Systems has seen its shares rise by 18% in just two days [166]. 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 [167].

As for Serbia, Air Serbia, the national carrier, is expected to return to pre-pandemic levels by next 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 [168].

Looking at Croatia, the 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 "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 [169].

Russia and Asia

Despite the fact that 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 [170], this sector could be one of the hardest affected by the conflict between Russia and Ukraine [3]. In fact, many foreign airlines have already stopped operating and maintaining their fleet in Russia. 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 [171]. Moreover, the fact that airlines have stopped operating in the country has also had an impact on 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 [172].

Similarly, the number of daily flights in Russia has declined rapidly. According to a report published by the Chinese flight-tracking platform Feichangzhun [171], on 24 February, when the military conflict in Ukraine began, the number of daily take-offs and landings fell by 19 per cent compared to 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 [173].

Leaving aside the crisis in Ukraine [3], the size of the market in China is expected to increase by USD 1.2 trillion by 2038 [174]. 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 sizes 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 they 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 the passenger traffic and the need to meet the demand and alleviate the actual capacity pressures. In this regard, China plans to build new airports by 2023, in cities such as Dalian, Chengdu, and Xiamen, and nine new runways at existing airports such as Shanghai and Shenzhen by 2030 [175]. Lastly, it is important to mention the government's "Made in China 2025" plan [176], 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 from 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

While a year ago the Latin American aviation market was expected to grow at a rate of over 4% over the next few years, the latest reports take a more optimistic view, with growth expected to be over 5%

between 2022 and 2027. 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 [177].

This growth 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 [178].

For the aerospace and aviation sector in Latin America, the strategic lines are, 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 these improvements in airport infrastructure can have a potential impact on 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 [179]. The fleet is expected to continue 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 [178].

On top of this, the continent is planning 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 [177].

4.6 Industrial Robotics/Automation Domain

4.6.1 Short-term Market Analysis

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 [180]. However, during this year, its trend seems to be upward again, and the market value is expected to rise from USD 24.35 billion in 2020 [181] to USD 33.75 billion by the end of this year [182].

Yet this upturn will not be the same for all industrial robots, just as the pandemic did not impact all robotic models equally. While conventional robots were the hardest affected due to declining investments in major industries such as automotive, metalworking and machinery, collaborative robots were not as badly affected. Following this trend, collaborative robotics is expected to experience a substantial growth due to multiple driving factors such as, growing adoption of automation in end-use industry and reduction in labour cost coupled with high precision work and high regional demand for collaborative robots and reach USD 1.71 billion by the end of the year [183].

This growth also carries over to other market segments that not only spared the crisis, but also managed to increase their demand even then. Drones, automated guided vehicles, and telepresence robots are some examples.

4.6.2 Long-term Market Analysis

According to MarketStudyReport [184], the global industrial robotics market is expected to register a CAGR of 10.35% between 2021 and 2028, acquiring a value share of over USD 87.79 million by the end of the forecast period. 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 artificial intelligence (AI) solutions represent a reliable alternative technology for the development of flexible and reconfigurable manufacturing systems to solve different production tasks.

As expected, the widespread use of robotics will, in turn, bring with it the need to verify and validate the programming behind the robots, so the demand for V&V services is also expected to grow significantly.

The expectations for this domain for the four markets covered by VALU3S, once the project is completed, 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 [185]. Indeed, the European industrial robotics market is growing at a CAGR of 10-11% during the forecast period 2021 to 2025 [186], [187]. 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 [188]. 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 are striving 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 [189]. 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. Its aim is 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 is gaining importance within industry [190]. 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 [191]. Moreover, according to 2020 statistics, countries with robotic capabilities in manufacturing use, on average, 80 robots per 10.000 workers, while Turkey uses only 30 per 10.000 workers, which is another important potential growth opportunity [192].

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 [193].

Concerning Israel, its robotics companies are growing at a high rate [194]. 4% of the high-tech sector is currently dedicated to this industry, and this figure is expected to increase considerably in the coming years [195].

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 the use of 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 [196]. This position is expected to be maintained in the coming years with increased investment in the robotics industry.

As far as the two Balkan countries analysed in this document are concerned, Serbia has joined the Centre for the Fourth Industrial Revolution Network this 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 artificial intelligence and machine learning, internet of things (IoT) and robotics, 3D printing, nanotechnology and biotechnology, among others [197]. 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 the field of robotics, the AI startup 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 US by opening offices in Munich and Boston [198].

Russia and Asia

Russia is not usually associated with the use or manufacture of robots. However, its low density of robots in industry indicated great potential for growth 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 [199].

However, with the recent crisis in Ukraine [3], it is currently difficult to predict the fate of the sector in the country. The closures of several automated plants have led to a decline in technological imports such as electronics and industrial robots in the country [200], so the predictions made a year ago may not be in line with the current market situation.

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% [201], [202]. 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 economies in the region, such as India, there is great potential for growth in the market under study [203]. In fact, India has already started marketing its own brand of robots [204]. 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 [205].

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 manufacturing industry and rapid digital transformation of 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. According to the latest report from Research and Markets [206], the industrial robots' market in Latin America 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 [207]. 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. Chile, meanwhile, 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 [206].

On the other hand, as in Asia, due to the offshoring of certain production activities to emerging economies, the deployment of collaborative robots is a good strategy for companies looking to improve productivity and increase the efficiency of fulfilment operations [208].

Chapter 5 Conclusions and Next Steps

This chapter draws conclusions and outlines key steps until the submission of the next and final exploitation activity report and short/long-term market analysis of the VALU3S project.

This deliverable briefly describes the activities carried out around exploitation and the market analysis within the VALU3S framework. It presents the key objectives of the market analysis and its methodology and explains the current exploitation landscape surrounding the project. Unlike D6.8 [1], where many partners had not yet started to carry out exploitation-related activities, during this second year, the percentage of participation in this task has already been high. Notwithstanding, during the next year, it is expected that even more exploitation-related tasks will be performed by the partners.

Looking at the KPIs that were set in deliverable D6.8 [1], the vast majority are expected to be successfully achieved given their current value after monitoring them jointly with the partners. However, the KPIs *Exp-KPI-2. Beta testing agreements* and *Exp-KPI-3. (Potential) agreements with early customers or stakeholders* are still far from their target value, so more effort is expected from partners on these two indicators. However, their value is comprehensible given that, in order to make such agreements, the maturity level of the outcomes or their technology readiness level is desirable to be high or close to what is expected by the end of the project. Consequently, the progress of these two KPIs mainly will be monitored during the next year in order to foster the target values. In case this is not possible, appropriate preventive measures will be taken and these target values will be updated again.

On the other hand, the market analysis of this deliverable should be considered preliminary. The situation in the analysed domains is conditioned by coronavirus and, above all, by the ongoing conflict between Ukraine and Russia. However, in order not to rely solely on mere expectations, a risk analysis will be carried out to assess and mitigate risks arising from the expectations of these analyses, such as changing trends, interest rate movements or even miscalculation of target markets.

In addition to this, the consortium held two workshops together the Horizon Results Booster [6] on business plan development and intellectual property rights (IPR) in March and April, respectively. The first workshop was given as part of the application made by VALU3S for Service 2, entitled as the workshop itself to enhance its existing business plan. In this lecture, the consortium received a tailor-made training and support with one of its KERs, namely the web-based repository that is being developed and populated with cutting-edge V&V methods and tools. More precisely, emphasis was put on market analysis, business strategy, operations plans and competitor identification and analysis. On the other hand, the IPR workshop discussed topics such as the importance of protecting IP, the current methodologies to protect the outcomes and the procedures to be followed. In particular, special emphasis was placed on patents, although it was pointed out that this is not always the best way to safeguard intellectual IP, highlighting other alternatives such as trade secrets.

The next steps in relation to deliverable *D6.21 Final report of exploitation activity and market analysis in the short/long term*, will consist of a market analysis both globally for VALU3S and individually for each partner, where strategic thinking should be done considering the final results of each organisation.

Lastly, the consortium intends to hold another workshop on IPR. To this end, contact will be sought with the European Patent Office [209] with a view to receiving more detailed training in this area. This will allow VALU3S partners to fully benefit from their inventions and to promote innovation and the protection of their investments.

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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. Although there are no notable updates compared to deliverable D6.8 [1], some of the partners that previously had not indicated what their KER would be have now done so, and the information for the latest partner to join the consortium, CARDIOID, has been included.

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 per unit 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 critic 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. As well for 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.1.2 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.

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 compartment.

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 aims to develop.

Stakeholders. Mainly OEMs from the agricultural domain.

A.1.3 Railway Domain

Bombardier Transportation Sweden AB

Organisation short name	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, BT will obtain as a result of the project 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. BT's market share will be 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 BT's competitors are Alstom and Siemens. BT 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 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 will must fulfil with strict standards and safety regulation in order to be certified. AI-enhanced techniques are not currently recommended, so the adoption of this kind of solutions in such a 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 standardization 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. One of the key parts to remove the driver or assistant form the trains is that the train should be able to recognize 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 issues, 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 their 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 market in next years.

On the other hand, several SME and star-ups (Railvision, OTIV, Cognitive Pilot, HORUS, Roboauto…) are offering an AI-enhanced solution for autonomous train operations. Although the maturity level is still very low, they will be a key agent (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 more efficient their train operations (cost) improving the punctuality and energy saving issues and keeping passenger comfort. The automation process is required.

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

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

4) Regulation agencies: They should define new ways to certificate AI based applications which are not any more deterministic but probabilistic. This paradigm changes needs new ways to deal with this 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 critic 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. As well for 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 open-source CPU test suite in the use case demonstrator will expectedly ease open-source processor 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 easy-to-use CPU test suite will expectedly ease verification of motion control systems and thus reduce costs for verification and validation efforts. A successful replacement of commercial processors with open-source processors in the use case while maintaining safety/security standard compliance marks an important step for 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 will result in overall cost reduction. Open-source designs might also reduce resource consumption such as die area and power. These reasons are an advantage 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 would be a distinctive advantage to competitors' products.

Users' profiles. Recently, increasing interest from the Railways Sector can be observed as well where safety critical applications up to SIL4 are a daily occurrence. Especially here a reliable supply chain and long-term availability guarantees are key requirements for open-source solutions.

Competitors. N/A.

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	To be defined during the 3rd year of the project.

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. And 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 solution faster than the others, which mean that it can be used in higher production capacities. 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 to supply the safety of the robot by avoiding from obstacles. And to teach the trajectory experienced user is needed. OTOKAR solution cancels the need for manual trajectory teaching and the need for experienced user. Moreover, in IoT concepts it is needed to reach the system from a distant server. Its cybersecurity hardware and software will enable 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	Collaborative robotic cell for disassembly.

Results to be obtained from VALU3S. ALDAKIN will obtain as a result of the project a hybrid robotic cell that will be able to interact with personnel with disabilities through natural language-based interfaces (voices and gestures). 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. Although due to the coronavirus the robotics market stagnated somewhat in 2020, it is expected to grow at a CAGR of more than 6% over the next few 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	To be defined during the 3rd year of the project.	
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. N/A.

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	QRTECH an EMBRON Company
Organisation type	RnD Services	
Business model	B2B	
Key exploitable results	New services for the automotive industry through increased organizational knowledge in cyber security and safe AI for embedded devices.	
Other domains	Healthcare	

Results to be obtained from VALU3S. QRTECH expects to develop algorithms for safety and security. Specifically, it expects to have a test bench that can implement testing of requirements related to cyber security for the automotive domain, for example penetration testing. On the safety side, it expects to create algorithms to automatically assess the uncertainties in AI detections, for the automotive domain.

Identification of market share. QRTECH currently holds a stabile 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 cyber security in conjunction with safety.

Key market drivers. There is an emerging standard for cyber security in the automotive domain; this is an opportunity for QRTECH, since it is currently developing technology for assessment of cyber security. An opportunity is also to apply uncertainty quantification of AI-based systems in relation to the new SOTIF automotive standard to assess performance of AI.

Market trends. Offerings in safe AI will increase, giving QRTECH 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 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 development manages of its customers. Secondary stakeholders could be the end user. The primary wants a reliable partner that makes it work. The secondary stakeholder wants it to work.

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. But 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 isn't 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 simulator 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 simulator 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	R&D projects and private consultancies
Key exploitable results	Risk Analysis web application for the secure design of industrial machinery according to ISO 31000.

Results to be obtained from VALU3S. STAM would like to achieve 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.

Identification of market share. It has been estimated that the Agricultural Robot market will grow by 21% during the forecast period from 2021 to 2023. Indeed, this growing trend make reasonable to assume the achievement of a minimum viable market for this kind of application.

Key market drivers. One of the main market opportunities will be to take advantage of the growing trend towards automation also in agriculture. However, there is still no clear legal framework in the process of risk assessment and requirements for such systems.

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, mainly active in the eCommerce (70%) and Agriculture 4.0 sectors (20%).

Users' profiles. Remote monitoring of self-driving vehicles, protection from malfunctions caused by unauthorized subjects; interact with humans as well as with the agro-system, a non-standardized, heterogeneous environment subject to even unexpected changes; reduction of the use of plant protection products through the early detection of pests or diseases and their targeted elimination; identification of weeds and their localized control.

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.

Rulex Innovation Labs SRL

Organisation short name	RULEX
Organisation type	SME
Business model	B2C
Key exploitable results	To be defined during the 3rd year of the project.

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 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 at VALU3S will work the agriculture and healthcare domains, it is also targeting the automotive and aerospace domains.

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	To be defined during the 3rd year of the project.	
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. N/A.

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 (3) 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 customers profile is companies manufacturing Cyber-Physical System. The domains of TRC customers are quite diverse: Aerospatiale, Automotive, Healthcare, Legal, etc.

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

The main challenge is to provide a tool that helps them 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 at VALU3S will work the agriculture and healthcare domains, it is also targeting the automotive and aerospace domains.

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.

QRTECH AB

Organisation short name	QRTECH	
Organisation type	RnD Services	
Business model	B2B	
Key exploitable results	New services for the medical industry through increased organizational knowledge in cyber security and safe AI for embedded devices.	
Other domains	Automotive	

Results to be obtained from VALU3S. QRTECH expects to develop algorithms for safety and security. Specifically, it expects to have a test bench that can implement testing of requirements related to cyber security for the medical domain, for example penetration testing. On the safety side, it expects to create algorithms to automatically assess the uncertainties in AI detections, for the medical domain.

Identification of market share. QRTECH currently holds a stabile 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 cyber security in conjunction with safety. It aims to expand its market share within the medical domain by applying the results in cyber security and safe AI to the medical domain.

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

Market trends. Offerings in safe AI will increase, giving QRTECH 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 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 development manages of its customers. Secondary stakeholders could be the end user. The primary wants a reliable partner that makes it work. The secondary stakeholder wants it to work.

A.2.5 Aerospace Domain

LieberLieber Software GmbH

Organisation short name	LLSG	
Organisation type	SME	
Business model	B2B	
Key exploitable results	To be defined during the 3rd year of the project.	
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. N/A.

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. N/A.

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 to digitalisation of V&V applications, testing as-a-Service (TaaS) applications will competitors of IMTGD. With scalability and level of simulation, IMTGD will challenge market.

Stakeholders. N/A.

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 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 tailored for Industry 4.0 applications which are combined with FIDO-compliant person authentication and node authentication.	

Results to be obtained from VALU3S. ERARGE has started to benefit from the field studies (UC11) to position its hardware-based V&V methodology within VALU3S context that can be applied to analyse the vulnerabilities originated from threats at low level system components. The hardware-based countermeasures of ERARGE, like HSM, secure gateway and authentication solutions, are used to protect industrial settings and cyber-physical systems by cryptographic means.

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-serviceoperations. ERARGE, has identified this gap in the market and VALU3S can help ERARGE promote its SCP countermeasure tools (HSM, namely PRIGM©; Secure gateway, namely Senstation©).

Key market drivers. The eIDAS initiative and the current cyber security trends mentioned by ENISA, FIDO compliance promoted by big players (e.g., Google) for the node and person authentication, 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.

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 process applied by these stakeholders, which are usually 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. An improved process and tool chain for the method "V&V of Machine Learning-Based Systems Using Simulators". 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 will enhance the prototype research tool MODIFI with support for automatic dependability and security testing of AI and machine learning algorithms for multi-domain applications. It will gain 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.

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.

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.

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. RISE's main competitors are other universities and research institutes in Europe. Since each academic organization has their own profile, it 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. BK'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. BK'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	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 aims to obtain a methodology intended to find remaining faults (after each individual component has been validated and verified) that would have effects on the whole system. Furthermore, it is interested in fault and attack injection methodology in simulated environment with human in the loop. Its focus is on automotive domain.

Identification of market share. Research within automotive sector.

Key market drivers. Automated (driving) systems within automotive domain are often validated and verified using simulation in an initial development phase. A methodology 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 this method available.

Stakeholders. Use case owners can be the main stakeholders. VTI is a non-profit organization, so it do 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	FRAUNHOFER IIS/EAS cannot pinpoint the key exploitable result at this stage of the project.

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 expects to obtain an improved version of the virtual validation framework FERAL. In the project, the institute aims to enhance 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. BK'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. BK'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. BK'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. BK'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 artificial intelligence.

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 artificial intelligence enhanced system in the railway domain.

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.

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. N/A.

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 they require 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 and IKERLAN 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. BK'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. BK'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. An improved process and tool chain for the method "V&V of Machine Learning-Based Systems Using Simulators". 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 will enhance the prototype research tool MODIFI with support for automatic dependability and security testing of AI and machine learning algorithms for multi-domain applications. It will gain 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.

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.

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.

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. The profile of RISE's customers, that ask for its services, are mostly OEMs and their subcontractors, and SME´s.

Competitors. RISE's main competitors are other universities and research institutes in Europe. Since each academic organization has their own profile, it 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. BK'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. BK'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 expects to obtain an improved version of the virtual validation framework FERAL. In the project, the institute aims to enhance 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 contribute to verification and testing strategies of traffic surveillance and car teleoperation pilots. The contribution will focus mainly on generating and planning of test scenarios of both of these pilots incorporating verification methods and tools developed in BUT.

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. N/A.

Stakeholders. BUT managers, department managers and automotive industry.

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	Healthcare	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 based on.

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. N/A.

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 based on.

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.4.2 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 both an Intrusion Detection System to provide V&V features in Wireless Sensor Networks (WSN) able to detect malicious attacks in a WSN and notify the attempts to the entity responsible of providing reactions, and a Machine Learning-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. N/A.

Market trends. N/A.

Users' profiles. N/A.

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

Stakeholders. N/A.

Universita Degli Studi Di Genova

Organisation short name	UNIGE
Organisation type	University
Business model	B2B
Key exploitable results	To be defined during the 2nd year of the project.

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 do not directly involved in the projects 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 will be an advanced model of a patient which will be used for verification purposes of infusion pump system. The model of a patient will be a 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	Automotive	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 based on.

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. N/A.

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 based on.

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	B2C
Key exploitable results	To be defined during the 2nd year of the project. NUIM will follow UTRCI lead in terms of marketing.

Results to be obtained from VALU3S. NUIM's results will 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.

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. TBD.

Users' profiles. Aircraft engine and aircraft engine controller producers.

Competitors. Since NUIM will collaborate closely with UTRCI, who are the domain experts, it will rely on their expertise regarding competitive products.

Stakeholders. NUIM's role in VALU3S will be primarily to support UTRCI. As such, they will be the primary stakeholders.

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. N/A.

Users' profiles. N/A.

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

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

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	Automotive	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 based on.

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. N/A.

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 based on.

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.

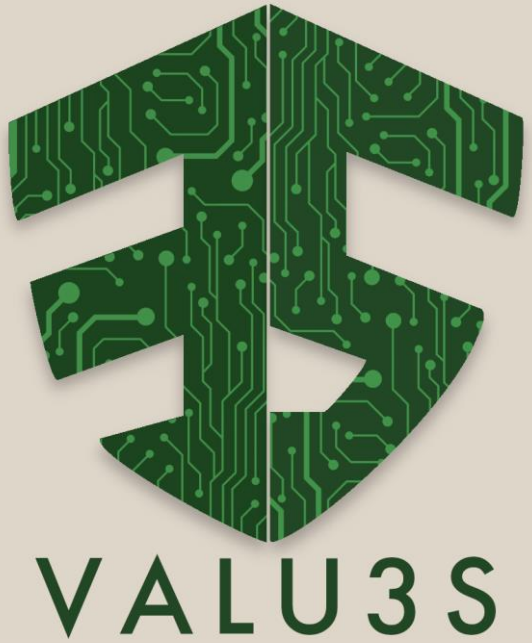
Key market drivers. Collaborative robotics is currently in the spotlight. Collaborative robots offer certain advantages over conventional robotics and do not limit the human task, but complement it. Therefore, specialising in the field of V&V in this new market niche can mean an increase in the services 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.



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