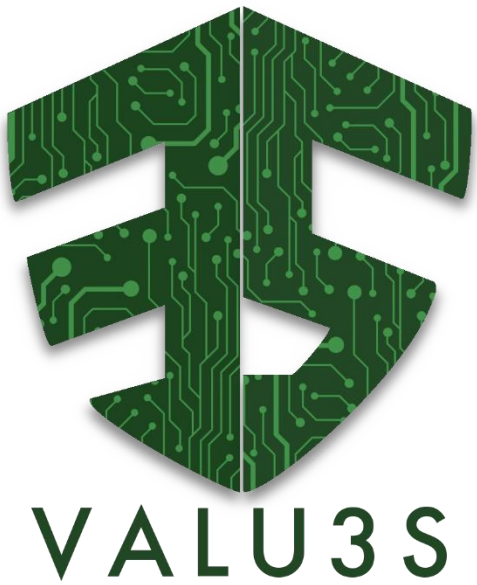

Verification and Validation of Automated Systems' Safety and Security

Initial Exploitation Activity Report and Short/Long Term Market Analysis

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Disclaimer

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Project Overview

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

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

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

In VALU3S, 12 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* (24 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
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Executive Summary

This deliverable (D6.8) is the initial exploitation activity report and short/long-term market analysis of VALU3S. It identifies the main activities related to the exploitation carried out during the first year of the project and the future actions established in this field for the second year. The deliverable also examines the different target markets that the results obtained within VALU3S may reach. The analysis has been done according to the domain in which they have been developed and the type of organisation that intends to exploit them.

Specific exploitable results will be identified, and the final exploitation plan will be reported by the end of the second year. Also, the market analysis will 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 deliverables in WP6 as well as deliverables in other works 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).
- D6.13. Final exploitation plan (Lead Participant: ALDAKIN, due: M18, Dissemination Level: Confidential).
- D6.16. Interim exploitation activity report and short/long-term market analysis (Lead Participant: ALDAKIN, due: M24, Dissemination Level: Public).
- 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 concretized 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 centralized 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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0.2	2021-02-26	Santiago González (ALDAKIN)	KPI definition
0.3	2021-03-17	Oihane Mayo & Íñigo Elguea (ALDAKIN)	Market analysis
0.4	2021-03-19	Íñigo Elguea (ALDAKIN)	Integration of partners' contributions

Version	Date	Author (Affiliation)	Comment
0.5	2021-04-09	Oihane Mayo & Íñigo Elguea (ALDAKIN)	Corrections after first review
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0.8	2021-04-28	Oihane Mayo & Íñigo Elguea (ALDAKIN)	Minor pending corrections
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1.0	2021-04-28	Behrooz Sangchoolie (RISE)	Final version to be submitted.

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Acronyms

AI	Artificial Intelligence
CAGR	Compound Annual Growth Rate
CDS	Clinical Decision Support
EBIT	Earnings Before Interests and Taxes
ECU	Engine Control Unit
EU	European Union
GDP	Gross Domestic Product
IoT	Internet of Things
IT	Information Technology
KPI	Key Performance Indicator
LRT	Light Rail Transit
NMT	Neuromuscular Transmission
OEM	Original Equipment Manufacturer
PCR	Polymerase Chain Reaction
PPE	Personal Protective Equipment
RAR	Russian Association of Robotics
RSI	Railway Supply Industry
RTO	Research Technology Organisation
SCP	Safety, Cybersecurity and Privacy
SME	Small and Medium-sized Enterprise
UAV	Unmanned Aerial Vehicles
VALU3S	Verification and Validation of Automated Systems' Safety and Security
V&V	Verification & 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 *D6.4. Initial Exploitation Plan* [1], this deliverable aims to present the activities conducted so far around the exploitation of the results that each organization will obtain, and the next steps to be taken in this regard, as well as to gather valuable data in order to facilitate the identification of the most viable target markets. This information will 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 them and the stakeholders will be identified.

Overall, the objectives of this deliverable are to:

- Present a report on the exploitation-related actions carried out during the first year of the project.
- Establish the objectives and exploitation-related activities to be carried out during the second 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 that entities participating in this task know their target markets so that the desired impact is achieved.
- Act as a preliminary document to be updated up to two future occasions (*D6.16 Interim Exploitation Activity Report and Short/Long Term Market Analysis* and *D6.21 Final Exploitation Activity Report and Short/Long Term Market Analysis*) during the end of the second and last year of the project.

Almost all partners (32/40) 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 be 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 will involve 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 results obtained.

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, the deliverable is structured as follows:

- **Chapter 2**: **Objectives and methodology for market analysis**. The second chapter of the deliverable describes the objectives of the market analysis for the project and defines which key performance indicators (KPI) are needed to measure that these objectives are successfully achieved. It also links these KPIs to the exploitation activities, thus relating the importance of market analysis in any exploitation plan. Finally, the methodology to 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 gives a summary of the activities conducted so far on exploitation and lists those activities that are expected to be undertaken in general during the second 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 COVID-19 [2] 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, currently including Turkey and Israel, 3) Russia and Asia and 4) Latin America. From each domain, there is a reference to Appendix A, where the specific market analyses for each partner can be found.
- **Chapter 5**: **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 in preparing a solid exploitation plan in order 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. The information gathered in this document will help to clarify the business model perspective to be defined in the next internal deliverable (*D6.13. Final Exploitation Plan*) that will be submitted on month 18.

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 and their intended target.

To establish these quantitative values, a survey was designed and shared with the consortium partners. However, since we are still at a relatively early stage of the project, many partners do not yet know the level of maturity of the technologies they will develop and, therefore, could not answer with certainty to several questions. Based on the results, these target values will be updated in the next deliverable (*D6.16 Interim Exploitation Activity Report and Short/Long Term Market Analysis*), through a second survey that will be shared with the partners during the second year of the project. Also, taking advantage of this survey, the status of each KPI will be monitored and analysed. In case of sub-optimal progress and/or not reaching the set targets, appropriate measures will be taken.

Table 2.1. Established KPIs with target goals.

KPI	DESCRIPTION	TARGET
KPI 1. Patents requested	The objective of this KPI is to promote the patentability of technologies developed to protect intellectual property.	≥ 5
KPI 2. Beta testing agreements	As is well known, 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. They are 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 commercialization of the technology to the beta tester.	≥ 45
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, commercialization partners (overseas representatives), funding partners, and alliances with actors covering other aspects of the value chain.	≥ 25
KPI 4. Teaching and academic education activities	This KPI aims to determine the number of master thesis and PhDs, as well as other types of education and training courses that can be carried out within the framework of VALU3S.	≥ 20
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 on 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

KPI	DESCRIPTION	TARGET
KPI 6. Spin-offs created	Many institutions sometimes take the strategic decision to centralize part of their activity independently. This KPI aims to quantify how many spin-offs will be created from the developments made within VALU3S.	≥ 4
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.	≥ 50

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 3.2. Actions Carried Out So Far and 3.3. Future Actions (2nd year)).

The deliverable *D6.13 Final Exploitation Plan* will contain a more in-depth analysis of the connection between the established KPIs and the specific exploitable results of the project.

Table 2.2. Mapping between KPIs and exploitation actions.

Actions / KPIs	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				
A8. Consider non-technical developments (legal aspects, privacy aspects…) and their influence on exploitation.		X	X				

Actions / KPIs	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 (32/40) actively participate in the process and contribute to its application.

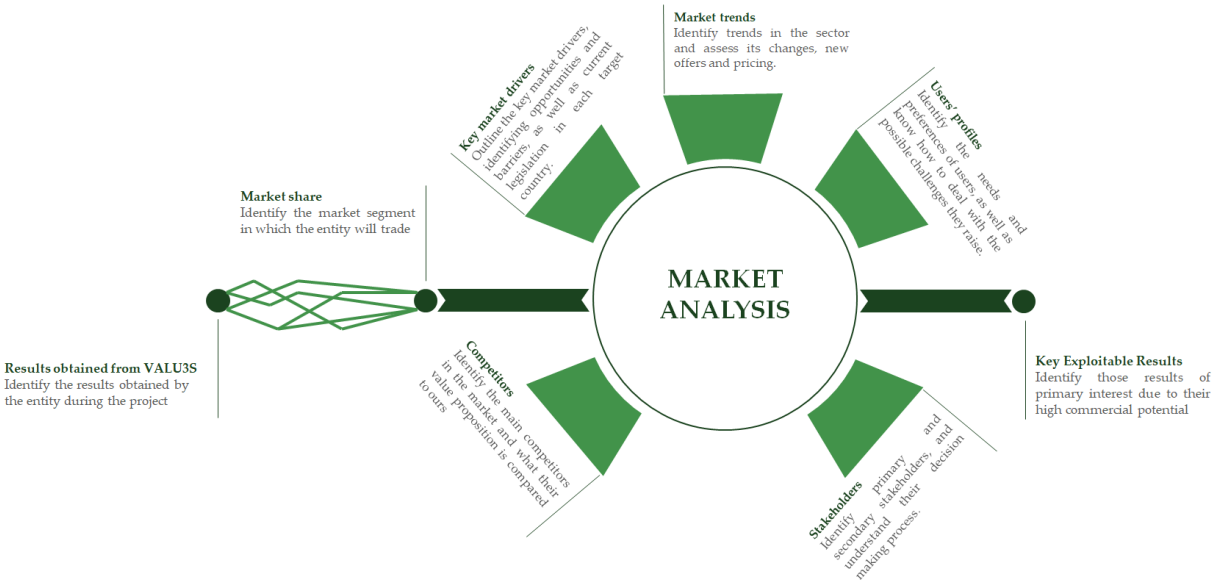

Figure 2.1. VALU3S market analysis methodology.

Firstly, for the specific analysis market, 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 results obtained will vary. In this case, the 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 has to 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 worked on in greater depth throughout the project, in deliverables *D6.16 Interim Exploitation Activity Report and Short/Long Term Market Analysis* and *D6.21 Final Exploitation Activity Report and Short/Long Term Market Analysis*. As the results to be obtained are better known, the market analysis will be more detailed.

Chapter 3 Initial Exploitation Activity Report

This section covers the activities carried out around the exploitation during the first year and the activities planned to be undertaken in the second year of the project. For this purpose, a short survey was shared with the partners where they identified each of these activities. In this sense, thanks to the market analysis made, almost all the partners identified what their major key exploitable result will be.

3.1 Actions Carried Out So Far

During this first year of the project, since the developments to be carried out do not have a high enough level of maturity, there have not been many partners working on exploitation-related activities. However, among those partners who have undertaken certain tasks, five main activities stand out.

1. **A1. Focus on the main results and their commercial viability**. Thanks to the market analysis, the vast majority 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 [3], 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 key exploitable results. Following the definition of "result", a key exploitable result 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 key exploitable results, 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 key exploitable results. These results can be found in Appendix A.
   These results are not only collected in this document but will be included within the VALU3S project as "Project Results" on the Funding & Tenders Portal of the European Commission, as they reach a high enough level of maturity.
2. **A5. Identify concrete customers' needs and describe ways to quantitatively measure the success**. Organisations have also focused on identifying their specific market segment and therefore the specific market customer needs to be covered. To this end, they have started to work on the definition of quantitative methods that allow, subsequently, analysing the impact caused on these needs and how they have been covered.
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 (2nd year)

For the second year of the project, it is expected that the activities to be carried out will be quite similar to those undertaken during the first year. Several partners, who have not yet carried out any activities in this sense, expect to start working on the exploitation of their results in more depth.

Also, some partners anticipate starting the intermediate exploitation of their results, which will allow the creation of new business opportunities before the end of the project. To this end, a major effort is expected to be made on intellectual property protection and on analysing how stakeholders could be interested in these results and how they could generate profits from their commercialisation.

Chapter 4 Short/Long Term Market Analysis

This section presents the short- and long-term market analysis for VALU3S. 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 (M12). More detailed versions will be published in the second (M24) and third year (M36) of the project.

4.1 Automotive Domain

4.1.1 Short-term Market Analysis

The impact of the Coronavirus pandemic [2] on today's globally integrated automotive sector has been accelerated and significant, with global production estimated to have dropped by 13% [4], and the number of cars sold by 15.3%, from 74.9 million units in 2019 to 63.4 million last year [5]. Initial concerns about the disruption of Chinese parts exports quickly turned into large-scale manufacturing disruptions across Europe [6]. In addition, the recession after the crisis itself, despite people's reluctance to public transport, reduced global car demand, which according to [7], will have a slow recovery that will lag one to two years behind the gross domestic product (GDP) rebound, associated with a U-shaped recovery at best (Figure 4.1).

[1] Please note that although Switzerland is outside the European Union, it participates 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 only Turkey and Israel.

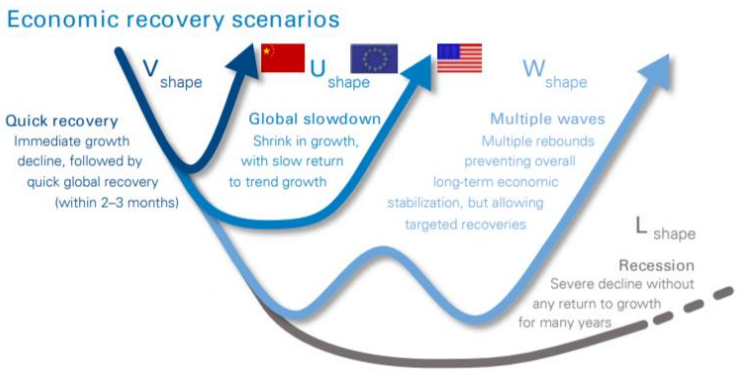

Figure 4.1. Economic recovery scenarios [7].

The recovery of the automotive economy in Asia, Europe, North America, and Latin America will largely depend on the impact of the pandemic, each of the containment and mitigation strategies, and their overall economic structure. In this sense, this recovery will be strongly conditioned by the regulation and government interventions. Likewise, manufacturers involved in this sector will need to create tailored strategies to mitigate the crisis.

4.1.2 Long-term Market Analysis

Amid the COVID-19 crisis [2], according to Oxford Economics data, a steady increase in automotive production output is forecast. However, the pick-up in activity will depend on how quickly manufacturing sectors can re-mobilise complex multi-country supply chains, which in turn depends on their supply chain strategy and risk management [4]. However, although the automotive market is in the midst of this slow recovery, according to the Automotive Aftermarket 2021 Global Industry Outlook Report [8], the global automotive market is forecast to reach USD 288.20 Billion by 2026 at compound annual growth rate (CAGR) of 3.7%.

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 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 [9]. 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.

While the coronavirus outbreak has wreaked havoc on the industry, forcing production to stop at a multitude of plants across the continent, a return to pre-pandemic economic activity levels is expected to occur by early 2022 [5], reaching figures not too far from those projected for 2025 before the crisis.

Milestones on the road to this future state include primarily developing a customer-centric mobility industry, achieving a leading position in sustainable mobility solutions, and creating superior and

sustainable economic value for all stakeholders [10]. These milestones will be driven in part by the market trends, where electric cars are taking the spotlight. Driven by a combination of increasingly stringent emissions regulations and changing consumer preferences, automotive manufacturers will need to seek economies of scale by building modular and scalable electric vehicle platform architectures.

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 [11].

Surprisingly, and unlike in other markets, the automotive sector grew considerably last year, as according to data from the Automobile Manufacturers Association, sales reported an increase of close to 60% [12]. Although it may be fluctuating, this market is expected to continue to grow in the coming years.

On the other hand, the Israeli automotive market has been affected by the pandemic, which has had a significant impact on sales. Over the last decade, the market has grown steadily, but after starting 2020 on a positive trend, the market collapsed with the arrival of the virus. In fact, annual sales last year fell by around 15% compared to 2019 [13].

However, the automotive market in Israel is expected to grow considerably in the coming years. Ridesharing, on-demand transportation, and autonomous cars are attracting a great deal of consumer interest, so Israeli automakers are increasingly investing in autonomous cars and technologies to support the growth of the automotive industry. Internet of Things (IoT) and Big Data along with the growth of investment in vehicle development by Israeli start-ups are transforming the Israeli automotive industry [14]. In addition, the country already has more than 60 companies manufacturing aftermarket products for the automotive industry and 50 companies supplying components to original equipment manufacturers (OEMs) and Tier 1 suppliers worldwide [15].

Russia and Asia

Sales of new cars in the Russian market in 2019 fell by 2.4%. And the decline in production turned out to be slightly more significant, by 2.5%. This is due to slowing economic growth, lower oil prices, and the devaluation of the Russian rouble, all of which affected consumer spending [16].

The 2020 results are not much better either. The closure of several Chinese manufacturing companies supplying Russian companies led to the shutdown of their production. The Association of European Business (AEB) published data on the market for new cars and light commercial vehicles in Russia in April 2020. Between January and March 2020, the market fell by 19.1%. A prolonged decline in sales was predicted. According to the 2020 results, experts speculated that the new car market would decline by 50% [17].

To improve market dynamics, the government allocated 20.5 billion roubles from the federal budget to maintain demand for Russian automotive products [17]. While currently a near stagnant market, Russia's economy is projected to demonstrate modest growth in the medium run.

Regarding Asia, already in 2019, global vehicle production in the Asian continent suffered a 7% drop due to the intensifying trade war between China and the US and the economic slowdown. This was coupled with the recent coronavirus crisis, resulting in another estimated 9% drop in vehicle sales in Asia-Pacific. However, key markets such as China, South Korea, Japan, and Taiwan have since recovered strongly, as consumers have responded quickly to a strong domestic market stimulus, including low-interest rates and tax incentives, and new models [18].

Far from the same for Southeast Asia, where continued closures in response to high infection rates [19], and limited fiscal responses by governments will mean that these economies will take longer to recover. Thus, while the commercial vehicles market for these regions was expected to register a CAGR of 4% by 2025 before the crisis [20], it is difficult for them to reach those figures today. In contrast, Asia Pacific will register a much higher CAGR, which will be most notable for electric vehicles [21]. This will be mainly due, like Europe, to new stricter emission regulations and subsidies for hybrid and electric vehicles, where companies such as Hyundai (South Korea), Toyota (Japan), or Nissan (Japan) already own several models.

Latin America

The South American automotive market was anticipated to register a CAGR of over 4.8% during the forecast period between 2021 and 2026 [22].

The Latin American market offers great potential for the automotive industry, as car ownership in the region is currently low and disposable incomes are growing at a very high rate [23]. Experts expect Brazil, Argentina, Chile, Ecuador, and Peru to drive the automotive market the most. Indeed, in Brazil, with the improving economy and increasing availability of credit to support the country's vehicle market, growing investment, and strong export demand, the country has witnessed positive growth in vehicle demand and sales.

Argentina is the second largest passenger car market in the region and strong incentive campaigns by OEMs are expected to further boost passenger car sales in the forecast period [22], [23].

Despite having experienced significant instability, due to issues such as inflation, and now a large number of COVID-19 infections [24], [25], the Latin American market will be a booming market in the coming years.

4.2 Agriculture Domain

4.2.1 Short-term Market Analysis

According to the Food and Agriculture Organisation [26], the spread of COVID-19 has mainly affected the agricultural market in two ways, both in terms of food supply and demand. The former, in turn, can be traced to two factors. On the one hand, the closure of borders as a means of preventing the transmission of contagion has made cross-border trade in the industry more difficult. On the other hand, depending on the stringency of the measures decreed by each government, it may have meant that

many agricultural workers remained at home for a period of time, resulting in crop shortages, clearly affecting the ability to supply the region.

On the demand side, it varied considerably depending on the price of food, the income level of consumers, socio-demographic status, consumption and purchasing preferences, and lockdown constraints [27]. Overall, during the first wave of the pandemic, the number of visits to grocery shops declined, while spending on food increased per visit. However, these foods were mostly related to long-life products and the consumption of a large amount of fats and carbohydrates [27]. Restaurants' closures did not help the agricultural sector either, which further reduces demand for certain types of food.

Notwithstanding, according to [28], from 2022 onwards, prices are expected to recover gradually, but to remain below baseline levels for some time.

4.2.2 Long-term Market Analysis

The uncertainties caused by the COVID-19 pandemic [2] make it complicated to determine how these will impact consumption, production, and trade in the coming years, at least quantitatively. The contraction in economic activity caused by COVID-19 is expected to weaken global demand for agricultural commodities.

Based on [29], two partial stochastic analyses were conducted to analyse the projections and impacts of the coronavirus crisis in the coming years. The first analysis simulated the potential variability of agricultural markets by considering several different scenarios based on historical variations while the second one only considered certain macroeconomic variables. According to both studies, as far as the economic recovery from this year onwards is concerned, prices are expected to gradually return to the baseline scenario over the next few years. Food demand is conditioned by two main factors; lower economic growth reduces food demand, whereas lower commodity prices support demand. However, the results differ depending on both agricultural commodities, and countries. Thus, while products such as tubers, rice, and wheat may be less affected, and depending on the country, even if demand increases, the impact on food consumption for oil and animal products is considerably higher. Overall, nonetheless, the long-term impact on food consumption is not expected to be excessively high.

This market will also see strong investment thanks to the digitalisation that is already underway in several countries. IoT and big data will have a major impact on smart agriculture and will be present throughout the entire food supply chain. As more smart devices and sensors are installed on crops, these will become more data-driven and data-enabled. However, this requires technology awareness and investment in infrastructure and connectivity in a sector where digital technology is not a common tool. For this, knowledgeable and skilled farm managers and workers will be required, as well as a cadre of well-trained consultants and service providers [30].

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 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, the European Union (EU) economy was expected to grow by 15% between 2019 and 2030. Due to the pandemic, the COVID-19 baseline has been revised downwards to 10% in the current baseline, including the COVID-19 shock (an annual difference of 4.5 percentage points in 2022-2030) [31]. This has also affected the European agricultural sector. However, as mentioned above, this situation will be reversed in the coming years and pre-pandemic trends will be recovered.

Cereal production is expected to remain constant over the next decade at around 278 million tonnes. Although wheat and barley areas will decrease, yields are expected to increase due to crop rotations and improved farming practices.

For oilseeds, the total production of sunflower and soybeans is expected to increase. This will result in a decrease in vegetable oil consumption and a progressive increase in demand for oilseed oils in the EU.

As regards protein crops, peas, beans, lentils, chickpeas, and other dry pulses, between 2020 and 2030, the area under these crops is expected to increase by 37% to almost 3 million hectares. The high demand for vegetable and protein sources should lead to an increase of around 30% in the consumption of this type of food.

Finally, for sugar beet products, production is expected to reach 16.2 million tonnes by 2030. Higher yields, coupled with a small increase in sugar prices, should improve the economics of the sector and help stabilise the sugar beet area above 1.4 million hectares [31].

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 [32]. However, due to the coronavirus outbreak, according to the Turkish Statistical Institute [33], Turkey's agricultural GDP declined around 50% between the third and fourth quarter of last year. Notwithstanding, according to Trading Economics [33], the market is expected to recover and by 2023, GDP is expected to grow over 60%.

As regards Israel, its agriculture is unusually 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, the country is expected to record a CAGR of 5.50% in the coming years [34].

Increasing technological progress and innovation, the high level of investment in research and development, and the potential expansion of water resources will be the main drivers of this growth. Indeed, the Israeli government itself plans to invest in a number of advanced technologies in agriculture, including precision farming, crop prevention technologies, and drip irrigation [34].

Russia and Asia

The agricultural market is one of the most stable markets in Russia. Among the country's most important crops are sunflower oil, cereals, and maize [35]. It has also become a major player in

international wheat markets in recent years, even surpassing the EU in exports. In the coming years, the country is expected to maintain this leadership, accounting for 21% of world exports by the end of the decade. High growth is also expected in the production of maize, soybeans, and other oilseeds, based mainly on improved yields and productivity [29].

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. Still, and despite the pandemic, crop production is expected to increase by more than 10% by 2029 compared to the 2018-2019 season [29].

The continent is a major producer of cereals, especially rice, with a share of production close to 90% worldwide [29]. Its contribution in rice, wheat, and other coarse grains is expected to remain stable over the next decade. In fact, India's production of rice and wheat will be one of the most relevant. Conversely, the reduction of maize stocks in China could create opportunities to diversify production into other commodities in this country.

Similar to other regions, the area under cultivation will shrink, so the increase in production will be driven by improved productivity. Expansion of irrigation and seed varieties will play an important role in this improvement [29].

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, has been partially halted. 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, income in each region, and its main markets [36].

Regarding oilseeds, soybean production has increased considerably in recent years, mainly in Argentina, Brazil, and Paraguay, where the expansion of land for the crop has been remarkable. This production will continue to grow in the next decade where more land will be allocated to soybean cultivation [36].

In terms of pulses, beans are one of the most important in the diet of many Latin American countries. In this sense, its production is expected to remain relatively stable, with a small growth rate of around 1% in the coming years [36].

For tubers, production has grown relatively slowly in the region. While in Brazil production has declined, in several Central American countries and in Peru, production has been increasing and is expected to continue to grow over the next decade [36].

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 [36].

Finally, the South American continent is the world's leading coffee exporter 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, coffee producers will face changing climatic conditions in the coming years that will make some regions unsuitable for coffee production [36].

4.3 Railway Domain

4.3.1 Short-term Market Analysis

The railway domain is one of the sectors that is continuously growing. At the end of 2019, rail transport had a record market value of 177 billion euros. Moreover, since 2017, the sector has experienced 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 are reflected in the number of kilometres of track in operation and the number of vehicles currently in service. Since 2018, the global rail network has been expanded by 23,300 kilometres and the number of vehicles has increased by 20,000 units [37].

However, it is noticeable that the COVID-19 pandemic has had a negative effect on the demand in this sector. Different countries have adopted massive restrictions and lockdowns impeding the transport of freight volumes and people in order to contain the spread of the virus. In the first half of 2020, an 8% drop in transportation volumes was experienced [38]. However, it is understood that this crisis is caused by a virus, something which is sudden and unexpected and not related to market deficiencies in the economy. Therefore, as the pandemic situation normalises, the rail domain will continue to experience significant growth in the following years.

The International Monetary Fund predicts that global GDP growth will be 5.5% in the current year 2021 [39]. The recovery in commodity prices is also expected to contribute to market growth. Developed economies are also expected to record stable growth over the coming years. The growth of the sector will also be driven by the increase of the population, urbanisation, and rising environmental awareness. Finally, global trends such as digitisation, automation, and decarbonisation of railways will increase its demand and growth by improving connectivity and increasing efficiency [40]. In addition, policy initiatives such as the European Green Deal will continue to benefit the demand for rail solutions [41].

Finally, it is important to mention that the aerospace domain has fallen drastically due to the COVID-19 pandemic [42]. This negative impact has been beneficial for the rail sector, as many users have preferred rail over aviation. Therefore, one of the challenges for this sector is to create much faster transportation modes (e.g., the Hyperloop concept [43]), in order to become more competitive compared to the aircraft industry.

4.3.2 Long-term Market Analysis

As mentioned above, COVID-19 has created a negative impact on the sector given the restrictive measures imposed by governments. This resulted in a diminution of the demand, labour shortages, and

the closure of manufacturing plants. However, as the pandemic subsides and manufacturing operations resume, the rail domain is expected to experience a rapid market recovery, known as the case of V scenario [37].

In 2020, the global rail market was valued at USD 723.2 million. For the following years, the railway domain is expected to reach USD 974.2 million by the end of 2026, growing at a CAGR of 4.3% during the forecast period 2021-2026 [44].

The different trends that justify this growth are the following ones: by 2050, the population is expected to grow to 10 billion, and the total proportion of the population living in urban areas will grow to 68% by 2050 [45]. In addition, governments are more aware of greenhouse emissions and pollution. To ensure these objectives, governments will develop strict governmental standards. On the other hand, in most countries, both infrastructure and rail rolling stock operations are owned by the government and the public sector. As the railway domain is one of the strategic lines of the whole government, they will continue to push for the funding of railway projects, which will result in boosting their growth. Finally, digitalisation will be a key aspect of the railway industry. Real-time information processing will play an increasingly important role in the coming years, as data from sensors, video, and situational awareness technologies can be exploited to drive cost efficiency, safety and to serve as a better user experience [46]. These connected technologies and functions have seen their advantages in the COVID-19 pandemic, where information dissemination and passenger screening are playing a crucial role in efficiently respecting imposed restrictions. Finally, many major manufacturers, such as Siemens or Wabtec, are using a range of sensors in their locomotives to use in conjunction with IoT and Big Data Analytics to make freight safe, fast, and fuel-efficient [47].

Europe, North America, and Asia-Pacific are the three largest markets within the railway domain, together accounting for 80% of the market. Rolling stock, infrastructure development, and services make up almost 90% of the market. In the coming years, North America, the Middle East, Africa, and Latin America are expected to grow faster than the industry [48].

The major players operating in the railway management systems market are ABB Group (Switzerland), Bombardier Inc. (Canada), Cisco Systems Inc. (USA), General Electric Company (USA), Hitachi Rail Ltd (Italy), Alstom SA (France), Amadeus IT Group SA (Spain), Thales Group (France), OptaSense (USA), and Trimble Inc (USA). In order to increase their product portfolio and market share, many of these companies are focusing on joint ventures, mergers, and acquisitions. Importantly, they are also investing in R&D activities to develop new products and to gain a competitive advantage [38], [49].

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 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 the following report [50], the European railway market is expected to reach USD 58.68 billion in value by 2023, growing at a CAGR of over 6%, due to several key factors such as the rise in urbanisation, increased investments by governments in the railway domain, and the initiative to create

clean transport. In addition, the EU is one of the top countries in the railway sector, with the longest length of electrified railways and one of the safest rail networks in the world, with about 218,000 km of active rail network [51]. The EU Commission, through various initiatives such as introducing legislation and inviting private industry players to advance the existing network, is committed to making its railway network more convenient for passengers. For example, the EU commission has a target of shifting 30% of freight over 300 km to other modes of transport (rail or water) by 2030 Moreover, Germany, France, and the UK constitute the largest transit market in Western Europe, accounting for 75% of the sector's investments. UNIFE expects the Western European market to grow by 2.3% thanks to investments in rolling stock in Germany and France.

On the other hand, the railway supply industry (RSI) is an important component of industrial growth, employment, and innovation in Europe. The RSI includes locomotive and rolling stock manufacturing, electrification, parts, and track manufacturing and signalling, and 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. In addition to this, the 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 digitisation and the development of innovative technology that makes it a globally competitive market. Automation, big data, and the digital transformation of the supply chain are transforming manufacturing processes, enabling the creation of benefits such as mass customisation, increased speed, better quality, and higher productivity. This strategic goal will be reflected in 2030, where the EU's IHR will reinforce its position as a world leader in the development of high-tech products and solutions [52], [53].

Finally, it is important to mention the major players operating in the connected rail market in Europe which are Bombardier, Bosch, Siemens AG, IBM Corporation, and Atos Corporation [50].

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

In the case of Turkey, the transport and logistics market is expected to grow at a steady growth rate of around 8% over the next few years [54]. This continued high growth is justified by the country's strategic location, as it is located between Asia and Europe. The transport market of Turkey includes the railway sector, and the projects that the country is going to push forward are the following ones: the government aims to build another 5,500 km of high-speed and fast rail lines by 2023 [55]. It has been seen that both transport habits and the country's intentions in relation to rail travel are changing. The use of cars and buses as a mode of transport has decreased significantly. Due to this trend, Turkey's fuel costs have been reduced. Moreover, this green railway alternative contributes to reducing carbon dioxide emissions and protecting the environment [56].

It is important to mention that the technical and engineering know-how in the railway domain has been improving and local companies of Turkey have carried out very successful projects in advanced railway investments. This qualification of personnel has led to Turkey being the eighth country with the highest start-up of high-speed railway operations in the world. Furthermore, the introduction of high-speed rail technology has boosted efforts for the development of the advanced railway industry and the creation of a domestic and national railway industry [57]. 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 it is also an exporting country thanks to the investments that have been made. This trend will increase in the coming years [55].

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 [58], [59].

Russia and Asia

The Russian railway system, one of the largest in the world, is of strategic importance to the Russian economy [60]. The railway domain in Russia is undergoing a major evolution with several projects planned. As a result, Russia is expected to invest approximately USD 84 billion in railway projects between now and 2026 [60]. The two main strategic lines driving Russia's railway sector are, on the one hand, freight transport and, on the other hand, passenger transport through the creation of high-speed trains.

On the one hand, Russia's current railway infrastructure and the network does not have sufficient capacity and capabilities to handle the growing traffic and increasing freight volumes expected in the coming decade. Therefore, Russia has plans to develop new transport corridors in order to experience a steady flow of goods in and out of the country. There are two strategic areas of interest to Russian freight: the Arctic and the Far East. The Arctic is a logistics development hotspot, with an expenditure of approximately $136 billion to ensure year-round Arctic transport by 2030 [61].

On the other hand, in considering the increasing 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 average connectivity of 700 km, with projects aiming to link Asia-Pacific regions. Also, over the next 5-10 years, new deliveries of electric multiple units (EMUs) and electrification of passenger rail infrastructure are expected to see a significant increase in demand across the region [62].

In the railway domain, Asia-Pacific is the region experiencing the strongest growth worldwide and it is expected to be the leader of the sector in the coming years. Asian economies, such as China, India, and Japan, top the list of passenger-kilometres per year. In addition, the major manufacturers in the railway market are based in this region [51]. The significant country within this region is India, as the railway solutions market is expected to experience a CAGR of 13% by 2026 due to increasing traffic intensity and the complexity of the railway system, which requires real-time traffic control systems [44].

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. As of 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% [61]. As a result, the Indian rolling stock market is experiencing steady growth through upcoming metro projects (13 operational, 6 under construction, 7 in the planning stage, and 8 in the proposal stage) and the extension of existing lines, and with the possibility of building a bullet train between Mumbai and Ahmedabad (Mumbai Ahmedabad High-Speed Rail Corridor) [48].

Finally, it is important to mention the Chinese railway market, which plans to restore and develop the ancient Silk Road between China and Europe, encouraging investment in Eurasian transport and logistics, including railway networks, to boost Chinese investment and economic integration [48].

Latin America

As mentioned above, one of the countries that will experience significant growth in the railway domain is Latin America. The Latin American freight and logistics market is growing enormously during the period 2020-2026. Within the sector, the Latin American rail components and infrastructure market will generate around USD 7 billion by 2026 [63]. Increasing passenger and freight rail transport is inducing demand for railway infrastructure upgrades across the region. In addition, Latin America is focusing on high reliability, high-performance trains at the lowest possible cost for its passengers, which is driving the market growth exponentially [64].

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 the construction of rail infrastructure to facilitate the connection of commodities to the main 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) - could be eligible for certification as green projects by the Climate Bonds Initiative (CBI), a non-profit organisation that mobilises bond markets to promote investment in projects and assets needed for the transition to a low-carbon economy [65].

4.4 Healthcare Domain

4.4.1 Short-term Market Analysis

According to Market Research Future's analysis [66], the impact of COVID-19 has affected all markets in general, except the healthcare market. The impact on this market is enormous and has severely disrupted the entire supply chain of the healthcare industry, from raw materials to manufacturing and delivery. Globally, the demand for medical ventilators has forced producers to increase demand by as much as 40-50%. For example, Philips has doubled its ventilator production capacity from about 1,000 ventilators per week to about 2,000 ventilators per week; Getinge has increased its capacity by 60% compared to its previous production capacity of 10,000 ventilators per week and Medtronic has increased its production by 40% [67].

In addition, considering the importance of this global pandemic, and considering that different countries were not sufficiently prepared to deal with COVID-19, governments and numerous

organisations have collaborated with other industry players. To meet consumer demands for vaccines, medicines, diagnostics, and medical equipment such as ventilators, major players are engaged in research and development operations, strategic alliances and partnerships, and the development of innovative products in a short period of time. For example, as of 30 March 2020, GE Healthcare and Ford Motors signed a strategic partnership. In the agreement, Ford Motors contributed its manufacturing capabilities to rapidly scale up production, and GE Healthcare contributed its clinical expertise and licensed the current ventilator design from Airon Corporation, a private US company specialising in high-tech pneumatic life support products [68].

It is important to highlight the impact that China's medical devices will have on the global healthcare market. During COVID-19, many countries have purchased test kits such as polymerase chain reactions (PCRs), personal protective equipment (PPE), and ventilators from China. Governments are likely to continue to support, encourage and promote Chinese companies with high-quality innovative products. The health insurance market will be further opened to foreign players and restrictions on innovative health insurance products are likely to be gradually removed. Finally, another important point was the use of information technology (IT) solutions in the pandemic. Most countries globally have accounted for the significant growth of the health IT sector and it can be attributed mainly to the high adoption of telehealth solutions, such as telemedicine or remote monitoring of vital variables [69].

4.4.2 Long-term Market Analysis

Despite the collapse that COVID-19 has generated in the health sector [70]–[72], it has grown rapidly due to the global pandemic and the importance of the health sector in addressing this problem. Given the effect it has had, this growth is expected to persist into the future. This growth includes several strong demographic trends that highlight the growing need for healthcare: the ageing of the baby-boom population, the growth of the middle class, and the increasing prevalence of chronic diseases [73]. By 2022, global healthcare spending is expected to increase at an annual growth rate of 5.4%, compared to 2.1% projected for global GDP growth over the same period. Furthermore, the global healthcare analytics market is expected to reach USD 50.5bn by 2024, up from USD 14bn in 2019, at a CAGR of 28.3% during the coming years. Factors such as government initiatives to increase EHR adoption, rising venture capital investments, growing pressure to curb healthcare spending and improve patient outcomes, the emergence of big data and artificial intelligence (AI) in healthcare are expected to drive the market growth.

The healthcare analytics market is highly competitive by nature, with several large and emerging players. According to MarketsandMarkets [73], the major players in this market are: IBM Corporation (USA), Optum, Inc. (USA), Cerner Corporation (USA), SAS Institute, Inc. (USA), Allscripts Health Solutions (USA), McKesson Corporation (USA), MedeAnalytics, Inc. (USA), Inovalon (USA), Oracle Corporation (USA), Health Catalyst (USA), SCIO Health Analytics (USA), Verscend Technologies, Inc. (USA), CitiusTech, Inc. (USA), Wipro Limited (India) and VitreosHealth (USA).

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 analytics market is expected to grow at a CAGR of 15% during the forecast period (2021-2026). The major factors driving the growth of this market are increasing data records in the healthcare sector and adoption of advanced analytics to provide data-driven insights at a faster rate [74].

Reducing the cost of care and predicting potential emergency services drive this market. With digitised health records, patient patterns and histories can be identified more efficiently. Digital devices, such as IoT and apps, are becoming an increasingly important part of the healthcare system in Europe; for example, in November 2019, the Digital Supply Act was proposed in Germany's federal parliament, allowing doctors to prescribe apps to their patients, which can be reimbursed by the German statutory health insurance. Apart from this, the use of connected devices that generate huge amounts of data is expected to increase significantly; this raw data can be analysed to make better medical decisions [75]. According to ETNO [76], the number of active IoT connections in healthcare in the EU during 2019 stood at 2.79 million and is expected to reach 10.34 million by 2025. According to a study conducted by the European Commission in 2018 [77], around 96% of doctors in the region were using electronic health records. Countries such as Estonia, Denmark, Finland, Spain, and Sweden are among the biggest adopters of eHealth, and its use is routine among doctors in these countries.

Europe dominates the healthcare IT market, with Germany and Italy having the largest shares due to the presence of well-established infrastructures, together with the growing number of private medical service providers, such as Sana and Helios. The key players included in the report on the healthcare IT market are Epic Systems Corporation, McKesson Corporation, Cerner Corporation, Allscripts Healthcare Solutions, Inc, Carestream Health, Siemens Healthineers AG, Agfa-Gevaert Group, athenahealth, Inc, eClinicalWorks, GENERAL ELECTRIC, GREENWAY HEALTH, LLC, Infor, Koninklijke Philips N.V., NXGN Management, LLC, Oracle, Siilo, BigHealth, Vida Health, SWORD Health, NOVIGENIX SA, Lantum, BD ROWA, Bioaxis and Ada Health GmbH [74].

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

As the disease profile changes and demand for higher quality healthcare infrastructure increases, the number of specialised healthcare facilities also continues to grow. The market will be constrained by economic headwinds as a result of the COVID-19 pandemic, and an already weakened economy following the 2018 recession. However, the large and fast-growing population, the expansion of healthcare facilities, and the Turkish Drug and Medical Device Institution’s strategy to expand medical device production will support the market growth [78].

Turkey, with a population of 83 million, is a growing market for the healthcare market, especially for medical technology and healthcare services companies. The Ministry of Health is responsible for planning and implementing the country's healthcare policy and it is also the largest provider of healthcare services. Turkey spends 4.5% of its GDP on healthcare; a relatively low rate compared to the OECD average of 8.8% and indicates that there is space for growth in healthcare spending. On the other

hand, Turkey is a major importer of medical technologies, with imports accounting for 85% of medical devices, 20% of which come directly from the US [79].

Within the healthcare domain, Turkey has the following strategic objectives that aim to boost market growth considerably: on the one hand, Turkey wants to increase the country's skill set and know-how to manufacture medical devices. The second strategic line focuses on the implementation of health information technologies in the different hospital centres. With COVID-19, Turkey has taken a very progressive view and the Ministry of Health has employed many solutions based on software developers. The Ministry of Health's "e-pulse" application allows citizens to access their health records, also it has developed applications to reduce diagnostic errors, it has supported telemedicine and it has chosen to develop remote monitoring solutions to address the pandemic. Noting the benefits that these previously described objectives have provided, it is clear that this trend will continue to develop in the coming years [80].

Within the healthcare domain, the Israel healthcare industry continues to strengthen and grow year by year [81]. 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.

Importantly, the healthcare market of Israel, is trending towards a more integrated ecosystem, converging biopharma, medical technology, digital health, and healthcare into a single bioconverged industry. This emerging health technology space has remarkable potential to have a transformative impact on the healthcare sector. This bioconvergent field has given Israel 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 of the economy of Israel [81].

Medical devices, biotechnology/pharma (including agro-biotechnology and therapeutics), diagnostics, health informatics (including telemedicine), and the "other" sub-sector remain the top five sub-sectors of the life sciences industry in Israel [82]. Notably, within the healthcare domain, there is a clear trend towards the design and development of medical devices, as, the number of companies involved in this sector has increased since 2018. Also, the healthcare IT sector is becoming much more important, with innovative solutions in this field [83].

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 premier destination for clinical trials, which offers opportunities for Australian biotech companies to work with Israeli groups, e.g., Israeli biotech companies - Azura Ophthalmics and Bioforum. In addition, the NSW-Israel Research and Development and Technology Innovation Program provided matching funding of up to A$250,000 for companies to work with Israeli partners in 2020. 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 [82].

The key players within the healthcare sector in Israel are the following ones: the IVC Research Centre, Trendlines Incubators Ltd., and aMoon Partners [82].

Russia and Asia

According to the following report [84], Russia's GDP is expected to grow by 4.4% per year on average in 2012-2030. Public and private investments in healthcare, according to this scenario, will grow to 7.1% of Russian GDP in 2030, up from 4.6% in 2010.

Although it is important to mention that COVID-19 has created a negative impact on this sector, given the collapse generated by the pandemic, healthcare industry players believe that gradual consolidation of the healthcare industry is inevitable in the current climate and full recovery of the sector is expected by 2023. Russia's strategic directions within the healthcare domain are all related to technological advances. On the one hand, it has been seen that the health consumers in Russia increasingly pay more and more importance to quick access to information and its specialists, as well as their own medical history and test results; the ability to book appointments online at their convenience. This leads to the digitisation of multiple hospital factors. On the other hand, Russia wants to implement high-tech medical examinations and surgical interventions, despite the cost of these services. Finally, telemedicine has taken an important role in the COVID-19 period and this trend is expected to grow in the coming years [85].

On the other hand, Russia is the largest market for medical devices in Central and Eastern Europe. However, it is the fifth smallest in terms of per capita expenditure. The national healthcare landscape currently has significant gaps, and it is significantly less advanced than in other developed countries. The Russian medical devices market is, therefore, considered to be a growing sector, currently valued at more than 429 billion roubles (5.052 billion euros) [85].

China is one of the few countries where the COVID-19 pandemic has been beneficial and has led to market growth. For the various severely affected countries, China has been the country of supply for sanitary workwear, such as masks, gowns, face shields, and others. The Asia-Pacific sanitary workwear market was valued at USD 404.55 million in 2019 and is expected to reach USD 830.79 million by 2027; it is expected to grow at a CAGR of 9.5% during 2020-2027 An example of this, are the countries such as China, India, Japan, and Malaysia, among others, which are driving the growth of the sanitary workwear market [86], [87].

The sanitary workwear market in Asia-Pacific is concentrated in a few well-established players: Alpha Pro Tech, Ansell Limited, Cardinal Health, Derekduck Industry Corp, O&M Halyard, Tronex International, Inc, Kimberly-Clark Corporation, Surgeine Healthcare (India) Pvt. Ltd [86].

Another of Asia's strengths in the healthcare domain is the medical device industry. It has been observed that the prevalence of chronic diseases such as diabetes, cancer, obesity, cardiovascular, among others, is growing considerably, which has caused an increase in the demand for cardiovascular, oncological, orthopaedic, and pulmonary devices. To reduce the costs of hospital care, the miniaturization of medical devices previously used in the hospital for use at home by patients, such as glucometers, blood pressure monitors, or heart rate monitors, has been encouraged. The current emphasis on disease prevention has led these companies to work on research and development and manufacturing of innovative technologies for medical devices. Governments have encouraged the investment in start-ups to make

healthcare services more affordable for end-users, which has led to greater penetration of these devices in the Asian market [88].

Latin America

The healthcare analytics market in Latin America is projected to grow in terms of revenue and increase at a CAGR of 15.58% during 2027. According to [89], Brazil, Mexico, and the rest of Latin American countries together form the healthcare analytics market in the Latin American region. Although the market in Mexico is relatively untapped, most provinces in the country have initiated some degree of cross-domain data warehousing, where integrated health-related data is being pooled.

The main applications of health analytics are expected to emerge in areas such as clinical decision support (CDS), personalised medicine, public/population health, clinical operation solutions, and policy/financial solutions. Countries such as Peru, Venezuela, and Argentina are similar to Brazil in terms of regulatory policies regarding health analytics. However, Colombia has an advanced healthcare system that identifies and establishes guidelines for health analytics services. Thus, the rest of Latin America presents a mix of an enabling environment and a resilient environment for conducting health analytics operations. But at the same time, decision-makers identify the potential of health analytics in health-related cost savings, which makes this region increasingly interesting for health analytics companies [89].

4.5 Aerospace Domain

4.5.1 Short-term Market Analysis

Taking into account all the domains mentioned in this market analysis report, the international aerospace industry is probably the most affected sector due to the pandemic [90]. The COVID-19 is affecting the global GDP and poses a significant challenge to the revenues, earnings before interests and taxes (EBIT), and cash flow of aerospace manufacturers and suppliers [91]. Airports, airlines, and other market players are experiencing a significant decline in revenues due to the lockdown and restrictions employed by different countries, requiring a strong, short-term, and disruptive response from the aerospace industry [90].

The decrease in demand for the aerospace industry has been reflected in several areas: stock prices of airlines and aircraft manufacturers are dropping and so are the prices for kerosene, while the oil price for Crude Oil WTI even reached an all-time low. At the same time, the fall of prices has impacted different aspects of the aerospace industry: according to data of April 2020, international passenger capacity has been reduced by over 91% against the original plan, where Europe and Asia-Pacific are the hardest affected regions. With the decrease of passengers, international airlines, airports, and airport operators are severely impacted. For example, airports around the world suffered a revenue hit of around $100 billion by 2020, with Europe and Asia-Pacific being the most impacted regions (around $67 billion). Major operators such as Fraport, Heathrow, and Aena have shown a decline of more than 12% in the first quarter and are expected to decline further, as passenger flights have virtually ground to a halt (95%). This current crisis has a knock-on effect and as a result, aircraft manufacturers and other

sub-sectors of the industry have seen their demand significantly affected. Suppliers with weak finances are losing key personnel and may not be able to recover. Global deliveries in 2020 resulted in a total of 723 aircraft, 42% behind 2019 and 55.3% behind 2018, marking the second consecutive year of declining deliveries [92]. On the other hand, the MSCI World Aero & Defence index (an average mix of aviation and defence aircraft and systems manufacturers and suppliers) shows a 21% drop since January, aircraft manufacturers, such as Airbus and Boeing face declines of 43% and 36% respectively, in line with the NYSE Global Airline index. In the case of paraffin prices, the impact reached an 80% drop. Finally, it is important to highlight that more than 50% of the world's commercial aircraft fleet is still non-operational, predicting the possibility of a long-term decline in the passenger aviation business [90].

4.5.2 Long-term Market Analysis

As mentioned above, the COVID-19 has significantly affected the aerospace sector and the effect of this pandemic is expected to last for years to come. In 2020, passenger traffic plummeted drastically and is expected to take 2-3 years to fully recover, as restrictions will be gradually eased. Airline losses have led to the cancellation or postponement of aircraft orders, thus reducing considerably the demand [93].

Despite the impact of the pandemic, several aircraft manufacturers have already started to increase their production rates and are expected to increase from 1 billion in 2020 to 327.96 billion in 2021, at a CAGR of 10%. The global aerospace and defence market is estimated to be valued at $1600 billion by 2025, growing at a CAGR of 3.5% by 2025 [94], [95].

Market growth is driven by factors such as the boom in the commercial aircraft segment, increased global air traffic, and increased military spending. Therefore, the market trend in the aerospace industry focuses particularly on the advancement of technology and innovation, the use of different manufacturing materials, and the decrease in aircraft fuel consumption and emissions due to the rise 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. Moreover, these technologies optimise manufacturing operations and reduce costs [96]. GE Aviation is a case in point, it is using machine learning and data analytics to identify engine failures, which increases component life and reduces maintenance costs. Boeing has successfully created machine learning algorithms to design aircraft and automate factory operations.

The major players in the aerospace market are Boeing Company (USA), Airbus (France), Lockheed Martin Corporation (USA), General Dynamics Corporation (USA), and Northrop Grumman Corporation (USA) [97].

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 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

In the case of Europe, the aerospace market is expected to register an annual growth rate of more than 2.4% over the coming years. The reason behind this growth is the strategic plan of the EU: the aviation industry is an important strategic line of business, contributing €300 billion (or around 2.1% of GDP) to

the European economy before the COVID-19 pandemic, as well as supporting around 5 million jobs [98]. Within this strategic line, the EU's strategic objectives are the increment of the European aviation industry, the 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 [99]. 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 the reduction of carbon emissions by 75% by mid-century. Besides, Horizon 2020 is one of Europe's strengths driving aviation research to achieve these mentioned goals. One example is the Clean Sky Enterprise [100], 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). Among them, Airbus dominates the commercial and military aviation market in Europe [101].

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

Turkey's aerospace industry is expected to grow at a CAGR of over 5% during the coming years [102]. This growth is driven, on the one hand, by the country's increasing 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, Turkey has a plan to increase exports in the aerospace industry by $10.2 billion by 2023 [103]. In addition, according to the strategic plan published by the country's procurement agency SSB, "Strategic Plan 2019-2023", the annual revenue of the aerospace industry is expected to increase to USD 26.9 billion by 2023. Also, by 2023, the domestic industry will cover 75% of military needs, up from 65% in 2018, according to the plan. Another of the plan's strategic objectives is the 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 [104].

To achieve these goals, the Turkish government proposes to restructure its defence export incentive system. Furthermore, it will launch a government-to-government sales scheme, while the Savunma Sanayi Baskanlığı will open defence export promotion agencies in 20 countries.

Israel is one of the pillars of the aerospace industry, as it is found in every phase of the global value chain, from the manufacture of aircraft components 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 that it offers in fields, such as low-cost but high-quality manufacturing for Western countries, innovation and entrepreneurship that produce advanced technologies (UAV automatic landing and take-off), and expertise with the use of advanced technologies and aerospace defence products [105]. The most important Israeli companies are Israel Aerospace Industries, Elbit, and Rafael. These companies have a diverse portfolio of products and services, including space and airborne reconnaissance systems, radar systems, UAV, avionics and electro-optical systems, munitions, tanks, and armoured personnel carriers. They produce structural components and parts and operate

maintenance, repair, and upgrade facilities. In addition to these companies, there are several hundred SMEs active in the sector operating on a smaller scale [106].

Russia and Asia

Russia's aerospace industry is one of the driving forces of the country's economy [107]. It is one of the sectors that invests the most in science and technology and employs a large number of qualified workforces. Products from the aeronautical sector and military aviation account for more than half of the country's arms exports. Although Russian military aircraft are popular, including newer versions, the civil aviation industry still lacks competitiveness and reliability in comparison to its competitors. For example, the Sukhoi Superjet 100 regional jet achieved limited sales even within Moscow's sphere of influence, but it is hoped that the industry can reverse this scenario with the arrival of the MC-21 [108].

The strategic direction of Russia's aerospace industry is particularly focused on investing in the development and production of its own aircraft, mainly in the military sector. The defence industry competes with major European and North American manufacturers for various contracts around the world, which increases the need to develop its capabilities. Moreover, Russia is currently one of the few countries in the world capable of producing different types of aircraft, from light, commercial, and combat aircraft and helicopters, to complex defence and space systems. This is an important competitive advantage for Russia, where the investment is justified as it demonstrates the potential of the segment for the Russian economy, industry, science, and education [109].

Russia's leading aviation companies are Aeroflot, Gazpromavia, Yakutia, Yamal, State Transport Leasing Company (GTLK), VEB-Leasing, Sberbank Leasing, PSB Leasing, and others [108].

The size of the market in China is expected to increase by $1.2 trillion by 2038 [110]. 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 $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 [111]. Last but not least, it is important to mention the government's "Made in China 2025" plan [112], 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

The general aviation market in Latin America is expected to grow at a rate of over 4% during the coming years. This growth is influenced by the presence of the Latin American aircraft manufacturer Embraer,

which is based in Brazil. Moreover, Brazil has the largest business jet fleet in Latin America and has the second-largest business jet fleet in the world [113].

For the aerospace and aviation sector in Latin America, the strategic lines are, on the one hand, enhancing the safety of general aviation. The fact that air transport has become safer due to the introduction of improved safety standards has triggered an increase in the acquisition of general aviation aircraft in the region. On the other hand, another priority is the modernization and creation of new airports, where these improvements in airport infrastructure may 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 [114]. The fleet is expected to grow further in the coming years, mainly due to congested roads and the fact that those who can afford to travel in helicopters are opting for this type of way for commercial operations [113].

4.6 Industrial Robotics/Automation Domain

4.6.1 Short-term Market Analysis

The recent economic downturn caused by the outbreak of the coronavirus [2] has severely affected the robotics sector, and the market is projected to exhibit a sudden downfall in 2020 that will last until 2021 [115]. Notwithstanding, this pandemic will have a varying impact on different types of robots. Traditional industrial robots are expected to be the hardest hit due to declining investments in important industries such as automotive, metals, and machinery. Consumer-based service robots will also be severely affected, mainly due to the fall in disposable income as a result of the pandemic. Collaborative robotics, on the other hand, as a booming market where its use is not limited to certain industries but rather more diverse, is not expected to be affected as much [116].

There are also market segments that have not only been spared this crisis but have managed to increase their demand. Drones, automatic guided vehicles, disinfectant robots, and telepresence robots are some examples. Indeed, many of the manufacturers involved in the robot market are diversifying their product portfolio and/or are introducing cutting-edge technologies related to disinfection (UVC light) and contagion control (monitoring temperature) in their robots [117], [118].

4.6.2 Long-term Market Analysis

According to MarketsandMarkets [116], the robotics market is expected to register a CAGR of 18.2% from 2020 to 2025, acquiring a share value of more than $175 billion by 2025. The automation of manufacturing processes using robotic systems is changing the way production systems are conceived in general. In this sense, industrial robots represent a reliable alternative technology for the development of flexible and reconfigurable manufacturing systems that solve different manufacturing tasks.

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, 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

The European industrial robotics market is growing at a projected CAGR of 6.85% for the forecast period 2018 to 2025 [119], albeit as aforementioned, it will have a small dip between 2020 and 2021. However, labour shortages in the European region and the involvement of digitalisation and AI are driving the growth of this market, where the automotive sector is one of the main demanders, as it includes robotics throughout its assembly line.

The German market for industrial robotics is the largest in the region, with 346 installations per 10,000 employees, followed by Sweden and Denmark [120]. This is why 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, which eventually increase manufacturers' profitability and improve operational flexibility. In fact, the European Commission itself advocates robotics as a strategic line in the digitalisation of the region through its Horizon Europe programme [121]. Therefore, robotics 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 [122].

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 [123].

Concerning Israel, its robotics companies are growing at a high rate [124]. 4% of the high-tech sector is currently dedicated to this industry, and this figure is expected to increase considerably in the coming years [125].

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

Russia and Asia

Russia is not usually associated with the use or manufacture of robots. However, its low density of robots in the industry indicates great potential for growth. The Russian Association of Robotics (RAR) predicts significant growth in robotics adoption over the next five years. This is mainly due to the five trends that indicate this could happen. The first is the government's intention to boost the development and application of digital technologies, including robotics. The second is the booming demand for educational robotics. In fact, in 2017 the educational sector was the heaviest adopter of service robots in Russia, accounting for 31% of service robots sold by the 10 leading service robot companies tracked by the RAR. Third, Russian robot manufacturers have set their sights on the service robot sector. Fourth, there is a growing market for industrial robots, and finally, Russian robot suppliers are focusing on developing applications and business models for SMEs to invest in robots [127].

In contrast, Asia is expected to record the highest growth rate during the forecast period. China dominates the regional adoption rate of robotics due to the massive deployment in the country's electronics and automotive sectors. Also, as these sectors are developing at a high rate in other economies in the region, such as India, there is a large potential for growth in the market under study [128]. Indeed, the market is expected to continue its dominance throughout the forecast period of 2018-2026 by exhibiting a CAGR of 10.86% [129]. The growing investments by major industrial players in the Asia-Pacific countries and the increasing government support are the key factors responsible for the growth in the Asia-Pacific industrial robotics market. Moreover, offshoring of production to reduce costs in the manufacturing industry and rapid digital transformation of it 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 other, means that Asia is going to 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. Specifically, this growth will be most notable in Brazil, where the Brazilian industrial robotics market was expected, prior to the crisis, to be the largest market in Latin America by 2021, generating around 36 million U.S. dollars, and the total Latin America market to reach 374.4 million U.S. dollars [130]. Also, 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 seeking to improve productivity and boost efficiency to fulfilment operations [131].

Chapter 5 Conclusions and Next Steps

This chapter draws conclusions and outlines key steps until the submission of the next 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.

Not many partners have started to perform exploitation-related activities in this first year of the project. This is understandable since many of them need to transform their products with the technologies they will develop. Therefore, they are still uncertain about some of the aspects required to ensure a solid market analysis. In this sense, it is expected that those partners who have not yet undertaken such activities will start to do so during the second year of the project. In fact, most partners feel that they will be more prepared to contribute to the exploitation of the project over the next two years, as the concepts will be more up-to-date and clarified.

The next steps concerning deliverable *D6.16 Interim Exploitation Activity Report and Short/Long Term Market Analysis*, which will include the interim exploitation activity report and a market analysis closer to what partners will find after the completion of the project, will be to encourage partners to start thinking strategically about exploitation, which will entail more in-depth specific market analysis. For this purpose, it will also be necessary to design a template that collects the information according to the type of organisation concerned, distinguishing between industrial partners, RTOs and universities.

Progress towards the achievement of the KPIs set out in this document will also be monitored and target values will be updated as appropriate.

On the other hand, the market analysis in this deliverable should be considered preliminary. The situation of the analysed domains is conditioned by COVID-19 and is expected to improve before the end of VALU3S. Nonetheless, so as not to rely solely on simple expectations, a risk analysis will be conducted to assess and mitigate risks derived from the expectations of these analyses, such as changing trends, interest rate moves or even miscalculating the target markets.

Furthermore, in terms of geographical market analysis, it is expected to expand the number of countries analysed within the European Market of Non-EU Member Countries and Neighbouring Partner Countries, so that new market niches can be covered. A clear view on market trends and how VALU3S results can impact and/or contribute to the different sectors will also be useful when updating the target values of the established exploitation KPIs.

Finally, the consortium intends to make use of the Business Plan Development service offered by the EC's Horizon Results Booster Team to support FP7/H2020 projects in improving their dissemination and exploitation activities and to truly maximize the impact and potential uptake in specific target markets.

The VALU3S consortium has the capacity to ensure maximum impact of its results in the different target markets. With the commitment and contribution of all partners, it can guarantee an effective market analysis that allows each partner to identify the smallest and most viable market.

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Appendix A Partners' Specific Market Analysis and Key Exploitable Results

This Appendix contains the specific market analysis and the key exploitable results identified by each of the partners that make up the VALU3S consortium.

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. Field-proven platform for creation of multifunctional and scalable intelligent vision-based and signal processing solutions.	

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 startup 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.

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. El número de nuevos actores que ofrecen soluciones digitales al sector agrícola está creciendo

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 validated and verified AI-enhanced object detector.	

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.

A.1.5 Aerospace Domain

United Technologies Research Centre Ireland

Organisation short name	UTRCI
Organisation type	RTO
Business model	B2B
Key exploitable results	V&V-verification suite.

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
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 2nd 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 COVID-19 the robotics market stagnated somewhat last year, 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 2nd 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 D-A-CH.

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. N/A.

Competitors. N/A.

Stakeholders. N/A.

Berge Consulting AB

Organisation short name	BERGE
Organisation type	SME
Business model	B2B
Key exploitable results	The most important outcome from the simulator is the increased speed of testing which will lead to an increased *number* of testing which will lead to *better* sensors and a *safer* society. BERGE will be able to do more, better and with fewer resources.

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	Exploitable results will be a deeper knowledge about agri-robot world, functioning and risk landscape, as well as an advanced Risk Analysis web-application tested in a real use-case during the project.

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 2nd 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	INTECS will use the VALU3S methodological solution and the acquired knowledge for increasing its technical lead and competitive edge in the company core domains, and for opening up new domains, expanding its consultancy portfolio for RAMS analysis and V&V, in relation with best practices and standards improved within VALU3S. INTECS aims to exploit the VALUE3S project results in its service-based core business, increasing the company's visibility, competitiveness and the returns in terms of new V&V consultancy offers, improved and more efficient customers support services.	
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. N/A.

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 2nd 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 D-A-CH.

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…).

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	INTECS will use the VALU3S methodological solution and the acquired knowledge for increasing its technical lead and competitive edge in the company core domains, and for opening up new domains, expanding its consultancy portfolio for RAMS analysis and V&V, in relation with best practices and standards improved within VALU3S. INTECS aims to exploit the VALUE3S project results in its service-based core business, increasing the company's visibility, competitiveness, and the returns in terms of new V&V consultancy offers, improved and more efficient customers support services.	
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. N/A.

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	QRTECH an EMBRON Company
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 2nd 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 D-A-CH.

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. COVID-19 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	To be defined during the 2nd year of the 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	To be defined during the 2nd year of the project.			
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	To be defined during the 2nd year of the project.	
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.

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	To be defined during the 2nd year of the project.			
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	To be defined during the 2nd year of the project.			
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	To be defined during the 2nd year of the project.
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	To be defined during the 2nd year of the project.			
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	To be defined during the 2nd year of the project.			
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.

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.

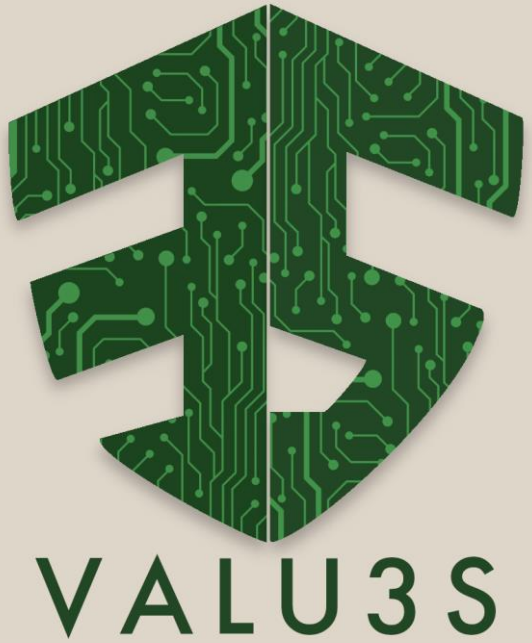
Key market drivers. Collaborative robotics is currently in the spotlight. Collaborative robots offer certain advantages over conventional robotics and do not limit the human task, but complement it. Therefore, specialising in the field of V&V in this new market niche can mean an increase in the services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