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MARKET ANALYSIS

ROBORDER

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Abstract: This document “Market Analysis” presents ROBORDER project’s preliminary results of the research and analysis towards exploitation and long-term sustainability plan. This document identifies the potential customers and existing competition, which ROBORDER system would have to face. Additionally, it covers other aspects of the exploitation and long-term sustainability plan, which were perceived as crucial to analyse for the first stages of ROBORDER system development.

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Executive Summary

This document presents the first version of the living document for Sustainability and Exploitation Plan for ROBORDER platform. The document presents the methodology created for the creation of sustainability and exploitation plan, including market analysis and business plan elements.

This deliverable presents the main elements and methodology behind exploitation plan, covering the business model, financial analysis, external environment, implementation roadmap and risk analysis. Market analysis and key trends are part of the foreseen external environment.

The main questions addressed in this study are:

- What is the market?
- How is the industry and its economy?
- Who are potential ROBORDER users and customers?
- What are their buying habits?
- How many of them are there?
- Who are ROBORDER competitors?
- What are the main competitors' activities, including the relevant challenges and successes?
- What are the regulations relevant to ROBORDER's operation?
- Who are key partners for ROBORDER system?

However, due to the specificity of the field and related secrecy, the information availability for market research was scarce. For instance, exact budgets of customers' spending or exact volume of the market were both not available. Nevertheless, the relevant aspects of the market understanding have been covered here, including, industry description and its outlook, and the rough estimations for market size.

On top of that, this market analysis also presents preliminary results of the business model analysis, including the key resources and the key potential partners for ROBORDER system development and exploitation. All information presented here lays down the ground for the future Business Plan and Exploitation and Long-term Sustainability Plan to be submitted on M24 and M36 respectively.

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List of Acronyms

Acronym	Meaning
DoA	Description of Action
EUB	End Users Board
KPI	Key Performance Indicator
PMB	Project Management Board
SAB	Security Advisory Board

Table 1 – List of acronyms

1 Introduction

The ROBORDER project addresses the call SEC-20-BES-2016 - Border Security: autonomous systems and control systems, of the HORIZON 2020 Work Programme for 2016-2017.

ROBORDER aims at developing and demonstrating a fully-functional autonomous border surveillance system with unmanned mobile robots, including aerial, water surface, underwater and ground vehicles, which will incorporate multimodal sensors as part of an interoperable network. The intention is to implement a swarm of heterogeneous autonomous vehicles and enhance it with detection capabilities for early identification of criminal activities at border and coastal areas along with marine pollution events.

The overall framework for the ROBORDER project lies in the domain of border surveillance, marine pollution detection and situational awareness. The main objective is to detect and recognize illegal border activities, assess conditions and properly indicate and inform the border authorities and operational personnel about the area status.

ROBORDER will collect various data from several different resources such as thermal and optical cameras, passive radars and RF sensors originated from multiple vehicles/robots. The data will be semantically integrated in order to provide accurate decision support services to the corresponding authorities for border patrolling.

The ROBORDER project's structure consists of 9 Work Packages as indicated below:

WP No.	Work Package Name
1	User requirements and pilot use cases
2	Sensing, robotics and communication technologies
3	Detection and identification of border related threats
4	Command and Control Unit functionalities
5	Integration of ROBORDER platform for the remote assessment of border threats
6	Demonstrations and evaluation
7	Dissemination and exploitation
8	Project Management
9	Ethical Requirements

Table 2 – ROBODER project Work Packages

ROBORDER will generate technical outputs with significant impact on the field of border security and surveillance. During the development of the project an impact assessment model will be developed to estimate the technical impacts of the ROBORDER implementation.

ROBORDER project seeks to develop an integral technology to cover existing gaps in border surveillance, aiming at prevention of cross-border crime such as trafficking (e.g. humans, drugs, etc.) and detection of potential threats. As such, ROBORDER beneficiaries comprise any officially recognised bodies involved in border protection, as well as other police services/departments. Close collaboration with governments and policy makers is, thus, envisaged.

ROBORDER reposes on unmanned vehicles and on the number of benefits this technology can bring. The drone technology is experiencing a rapid expansion and is likely to keep growing both in terms of numbers of units produced and in terms of applications, which will cover many different sectors (from public safety to leisure, from agriculture to e-commerce)[1].

Today's market evolution, as one will discover by reading this analysis, strongly relies on three main elements:

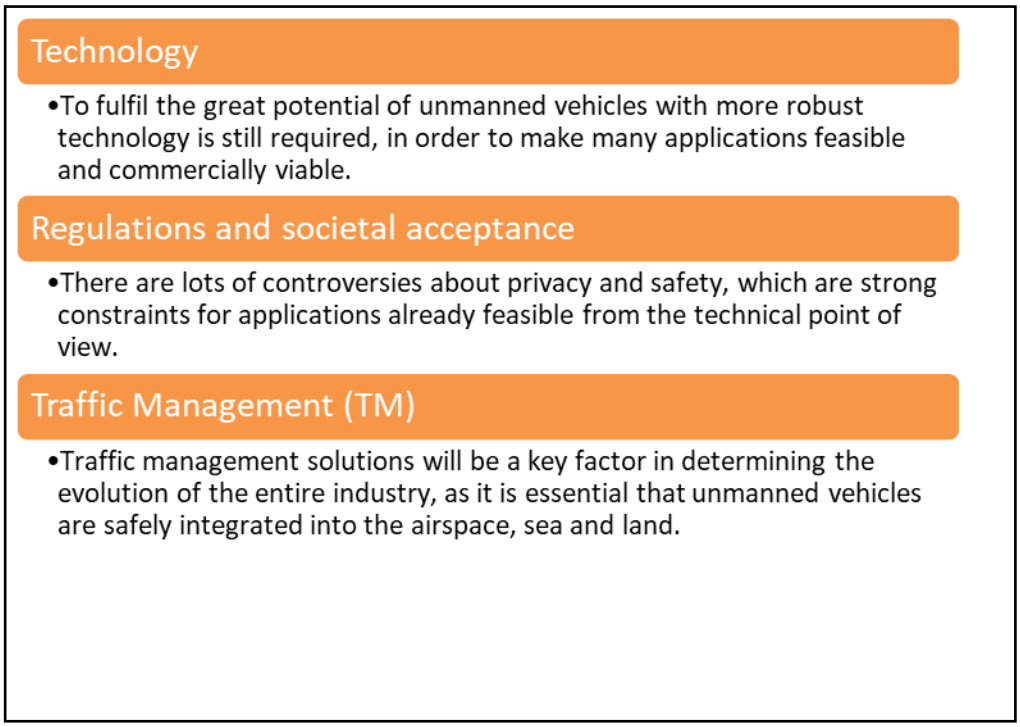

Figure 1 – Three key elements for the drone market to further evolve

This document is structured as follows. Second chapter presents ROBORDER's approach to exploitation and long-term sustainability of the project results, and the methodology applied for the market analysis. The third chapter provides the economy and brief introduction to the industry and its outlook. Market size and key trends, especially relevant for ROBORDER's value proposition are tackled in the fourth chapter. Fifth and Sixth chapter dwell on key resources and different hardware and software components, essential for ROBORDER system's operation. Seventh chapter presents the extensive competitors analysis and remarks on the competition. Key activities for ROBORDER are covered in chapter eight, and the potential users and customers are portrayed in the chapter afterwards. The relevant aspects of procurement are also identified there. Legislation relevant to ROBORDER operation is analysed in chapter ten and the preliminary analysis of the key potential partners

[1] European Drones Outlook Study, SESAR Joint Undertaking, November 2016

takes place in chapter eleven. Chapter 12 concludes with preliminary overview of value proposition.

2 ROBORDER's Approach to Market Analysis

2.1 *The ROBORDER's Approach to Exploitation and Long-Term Sustainability*

Market analysis is part of the ROBORDER's WP7 (Dissemination and exploitation), which aims at identifying ROBORDER's potential market. The deliverable "Market Analysis" is part of the overall goal of creating an exploitation and long-term sustainability plan and feeds in the future final report D7.8. The structure of overall ROBORDER exploitation and long-term sustainability plan, which is going to be achieved with D7.8, is presented in the figure below.

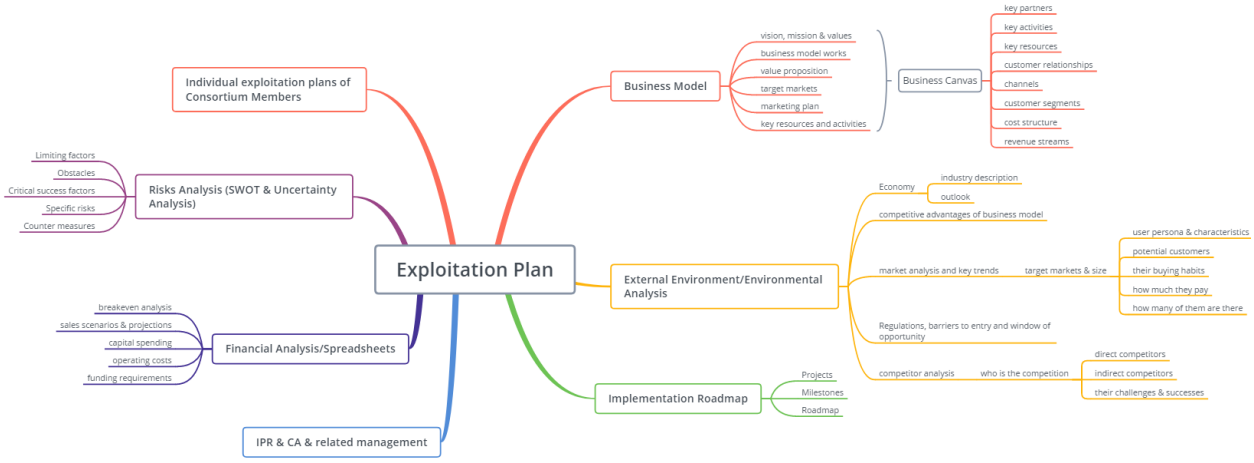

Figure 2 – Exploitation and long-term sustainability ROBORDER Plan

There are many methodologies and different techniques, how to analyse the exploitation or long-term sustainability possibilities of a product or a service. This plan is a preliminary version of the roadmap to understand ROBORDER's sustainability. As figure shows, the exploitation plan encompasses 7 main areas and is going to include business model, environmental analysis, implementation roadmap, IPR and other related management issues, financial analysis, risks analysis and possible individual plans of each consortium member.

This finalised 7 sections' exploitation plan (D7.8) is expected to provide a complete overview on how the innovative aspects of the project are going to be sustained even after the end of the project. Due to the nature of H2020 projects, individual exploitation plans play a key role in the long term sustainability of the project results. Partners are responsible and encouraged to ensure and proceed with the commercialisation of any innovation of systems, technology and/or tools, created during the ROBORDER's project meantime.

2.2 *ROBORDER's Market Analysis Coverage*

As mentioned earlier, this deliverable provides a background study on ROBORDER's exploitation and sustainability related aspects. The specific elements, covered in this study, are marked ✔ (as seen in the figure below) in order to provide the actual coverage of the D7.3 deliverable within overall goal of D7.8. It is approximately a one third of the overall requirements to be covered within the official duration of the ROBORDER project (36 Months).

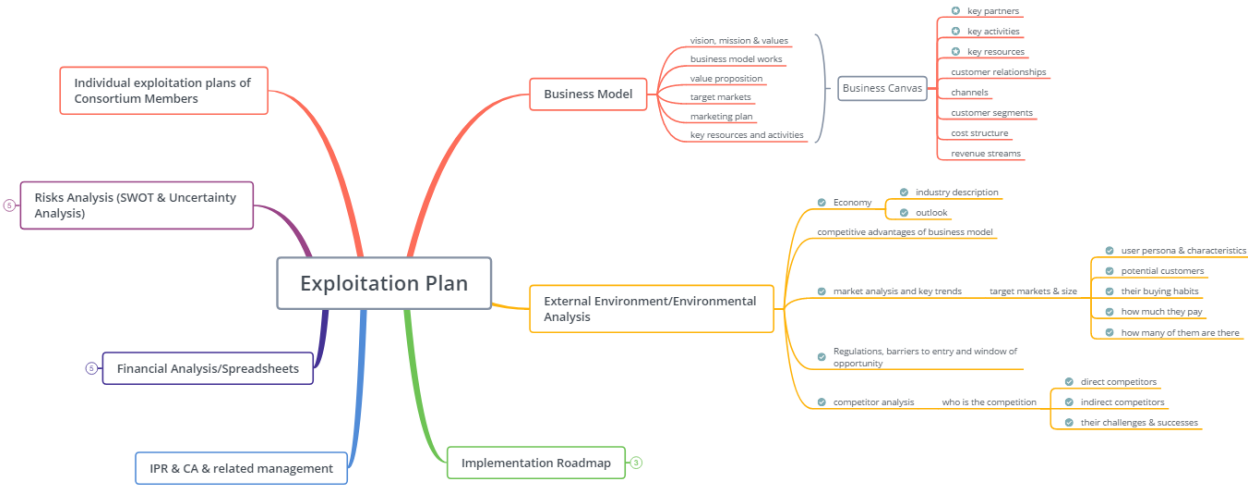

Figure 3 – Exploitation and Long-Term Sustainability Plan's aspects covered by ROBORDER project Deliverable 7.3 Market Analysis

The main objective of this task is to analyse the potential market for the outcomes of the ROBORDER project and to better understand the market of defence and borders' security. Ultimately, this market analysis should contribute to improving ROBORDER's services, provided to companies, organisations and public institutions working in this area.

Additionally, there are other reasons for doing market analysis:

- identifying the end-users and potential customers (which can be separate entities);
- testing the concept and the perceived added value, developing new strategies;
- solving business challenges;
- discovering new business opportunities.

In brief, market analysis is the first step in understanding the possibilities and opportunities for ROBORDER's long term sustainability and exploitation's prospects. This study also covers the factors relevant for the SLEPT (social, legal, economic, political and technological) analysis and paves the way for the future SWOT analysis.

2.3 *Market Analysis Matrix Overview*

Market analysis, as mentioned earlier, plays a key role in the success of the product or service. It is meant to provide a deep understanding of potentials customers, who they are, and what exact needs do customers have. Usually, market analysis equally dwells on industry overview, target market, competition and pricing, however, due to ROBORDER project's specificity, not only pricing, but even customers' overview are not properly available. Exact spending on specific security options, tools, software and hardware is never available, and the customers are not the end users. This *problematique* significantly affects availability of data and accuracy of forecasted success of ROBORDER in the existing market.

The most important elements for a market analysis are Market Analysis Matrix covers the following items: characterization and determination of market actors (service providers, manufacturers, etc.), external analysis from the perspective of the environment, competition and trends, analysis of regulations associated with the sector/product, analysis of the main drivers for demand for the product, service to the customer (quality, price, specific technical knowledge, innovation, credentials, etc.), and the analysis of the potential market (volume,

growth trends, etc.), as portrayed in the picture below. This analysis within ROBORDER's exploitation plan is called "Environmental analysis", as it represents the analysis of external environment, and this terminology is used interchangeably with market analysis.

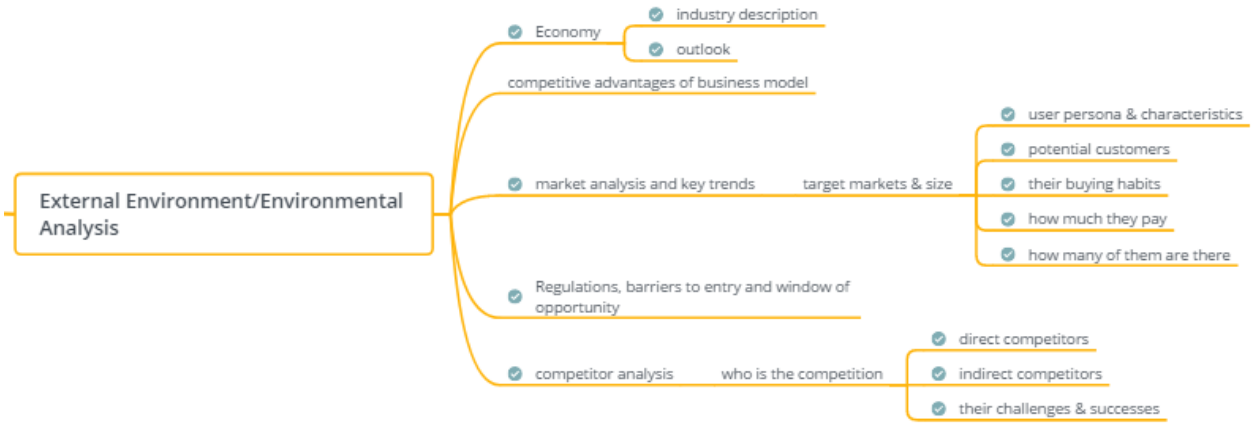

Figure 4 – The external analysis' elements covered by the D7.3 (study on market analysis)

There is a chapter dedicated to each ROBORDER's external analysis' element. In this regard, every chapter in this document starts with a brief overview of key aspects to be covered and the most important questions to be answered.

It is important to note that one of the environmental analysis elements, which is competitive advantages of business model, is not covered in this document, as it can be done only after the completion of business plan. As it is in most of the cases, market analysis and business plan are presented together, and for this reason the line between the two is not well defined. As a result, some elements from the external environment have not been covered or covered just partially, and consequently, some additional elements have been included from the business model category.

2.4 *ROBORDER Sustainability Framework Elements in D7.3*

As has been indicated in the section beforehand, this deliverable covers also relevant elements from the Business Plan, which are presented under the "Business Model" branch in the ROBORDER's exploitation and long-term sustainability matrix. The remaining elements are presented in detail in the following deliverable of business plan of ROBORDER.

As the figure, entitled "ROBORDER Sustainability Framework" shows below, there are several key aspects to be analysed in order to produce a sound business plan. This Sustainability Framework is based on Business Model Canvas[2], one of the most wide-spread methodologies for the new industries, providing an innovative approach to business models. Its strength lies in blending traditional and bleeding-edge models and their dynamics with innovation techniques to have a value-creating business model for companies, customers and society in tremendously transforming industry landscapes. This game-changing methodology strongly influenced the ROBORDER's approach to exploitation and long-term sustainability, and consequently, the most relevant elements have been adapted to meet ROBORDER's purpose and goals.

[2] [2] Alexander Osterwalder and Yves Pigneur, *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers.* New Yersey: John Wiley and Sons, Inc. 2010.

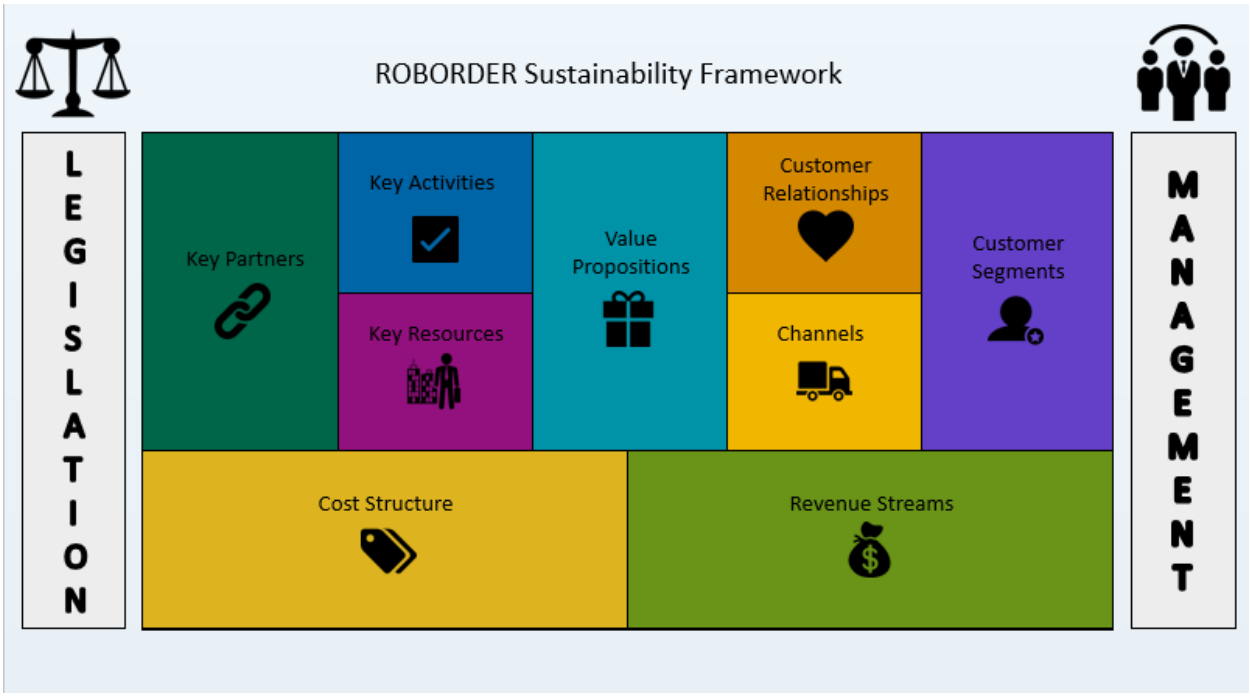

Figure 5 – The ROBORDER Sustainability Framework based on Business Model Canvas

This business model canvas is a global standard used by millions of people in companies of all sizes. It is a strategic management template for developing new (or documenting existing) business models. It is a simple visual chart with elements, describing a company's value proposition, infrastructure, customers and finances. This particular template has been adjusted and adapted for ROBORDER purposes, to make sure it also includes a list of key questions for each one of the identified areas for ROBORDER. In this way, the project team was able to describe, design and challenge ROBORDER's long-term business model.

The market analysis, as well as the business plan, deliverables are part of the exploitation plan and therefore based on this canvas. The Exploitation plan is a living document, which is continuously evolving throughout the project. The analysis is a continuous work towards the main goal of the exploitation activities, which is to understand how ROBORDER system will fit in the market.

2.5 *Methodological Aspects for Market Analysis*

The knowledge, contained in this analysis, comes from 2 main sources: an extensive desk research done "locally" and the insights gained from the exchanges with key players of the industry, especially, with the members of ROBORDER consortium.

For the desk research, conducted over a 14 months period till October 2018, both public domain materials, and the private information from market actors has been collected and interpreted. Sources of information include official and public reports from agencies and organisations, EU publications, national regulations, company's official websites, press articles (both general and industry specific) and other ROBORDER deliverables.

Exchanges with the key players occurred via phone or physical interview (ROBORDER plenary meetings in Budapest and Sheffield and WP7 monthly meetings online) and from the

answers to questionnaire shared via email. The questionnaire's main goal was to collect end-users, customers and related opinions about ROBORDER's concept and its added value. The questionnaire and the interviews prepared are in fact mainly based on the desk research in order to capture and understand the real value proposition of ROBORDER in end-users eyes.

As ROBORDER is an innovation project with a strong focus on developing a product to support autonomous border surveillance, positioned to provide LEAs, military units, and other international organizations with the capacity to monitor their borders effectively and with a relatively low total cost, its market analysis focused exclusively on the border security market. Border security refers to the measures taken by a country to monitor or regulate its borders: infrastructures, air/ground/water surveillance and detection activities. Since ROBORDER is foreseen as a system, a special attention has been paid to a smaller part of the market concerning the border security systems.

The market analysis concentrated mainly on the European Market, since the project has received funding from the EU's H2020 research and innovation programme and project itself concentrates on the protection of the EU's external borders. However, relevant competitors, legislation, regulation and other units have been covered regardless their non-EU/non-European scope.

2.6 *Defining Market Actors*

In this analysis, the four types of actors have been identified: end users, customers (procuring agencies or other buying institutions), competitors, vendors and partners (or potential mediators).

LEAs (Border Police, National Guard or other border forces), military units, international organisations and agencies are all considered potential users of ROBORDER system. However, the potential customers are internal or international affairs ministries and EU agencies responsible for border security (e.g. Frontex or Europol) and control and their procurement. The specificity of the market is that due to public procurement and secrecy in the area, it is not exactly clear how the process is done, especially for acquiring software and hardware for security purposes. The same EU agencies can be both – customers (buying the software and equipment and providing them to Member States) and partners, which facilitate the uptake of technology by majority of the partners.

The organisations were perceived as competitors, if they are or were offering a global border security solution/s (like ROBORDER) or more or less similar solutions to ROBORDER. An extensive list including defence and security contractors, high tech companies and manufacturers has been drafted and an accurate analysis of the solutions relevant to ROBORDER concept has been done. This list has been verified with Consortium representatives of end-users and customers.

Some of the EU agencies and international organisations, which could potentially be somehow interested in ROBORDER system (implement, help building or even purchasing the system), have been perceived as ROBORDER partners. The methodology followed to define the partners was based on the one for market definition, all organisations involved in one or more of the following aspects – homeland security, border surveillance, UxVs[3] and ATM, law enforcement – have been considered and analysed with a particular focus on finding common elements between their activities and ROBORDER concept. From a

[3] Unmanned Vehicles (of any type)

legislative point of view, also EU or international bodies, responsible for legal actions concerning border security, ATM and unmanned systems were considered as partners too.

2.7 *The Market Approach and Structure*

The figure below represents the relationships between the market analysis' framework and the relevant deliverable's chapters.

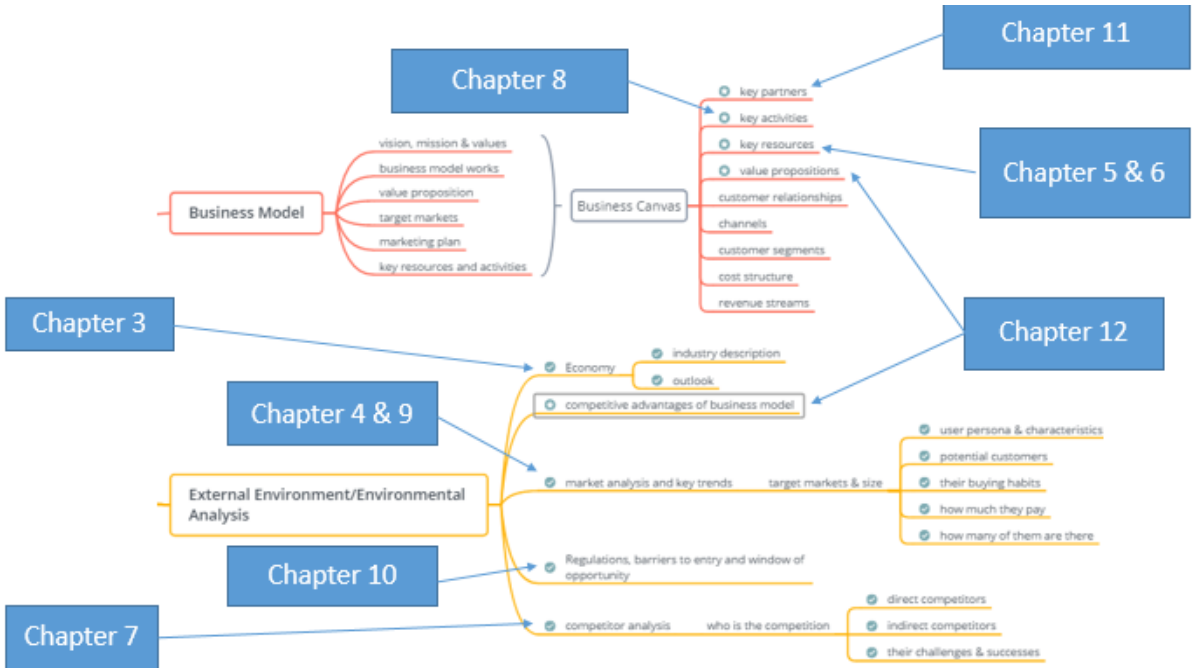

Figure 6 – Market Analysis Presentation within the Deliverable

3 The Economy: Industry Description and Outlook

3.1 *The simultaneous crises of irregular migration and terrorism*

In the EU, the topic of borders and border security is among the highest political priorities. The simultaneous crises of irregular migration and terrorism have each placed unprecedented pressure on one the Schengen Area, one of the cornerstones of the European project: open borders and the free movement of people, goods and services.[4]

Frontex Risk Analysis for 2018[5] shows that the rise in detections on the Western Mediterranean stands out against the overall decrease in detections of illegal border-crossing and suggests that the actual pressure exerted on the external borders stays high. Geopolitical and economic drivers of migration are on the rise and the EU remains exposed to large migration flows.

Irregular migration by sea, and more specifically via the Mediterranean routes, will remain the main modus operandi for illegally crossing EU's external borders and also one of the most dangerous forms of migrant smuggling, which often requires humanitarian assistance efforts.

[4] https://www.aspi.org.au/report/fractured-europe-schengen-area-and-european-border-security

[5] https://frontex.europa.eu/assets/Publications/Risk_Analysis/Risk_Analysis/Risk_Analysis_for_2018.pdf

To tackle this phenomenon, cooperation among maritime security players and shared use of assets are gaining momentum.

The following picture, taken from the Frontex Risk Analysis for 2018, shows the numbers of detections of illegal border crossing at EU borders in 2017,

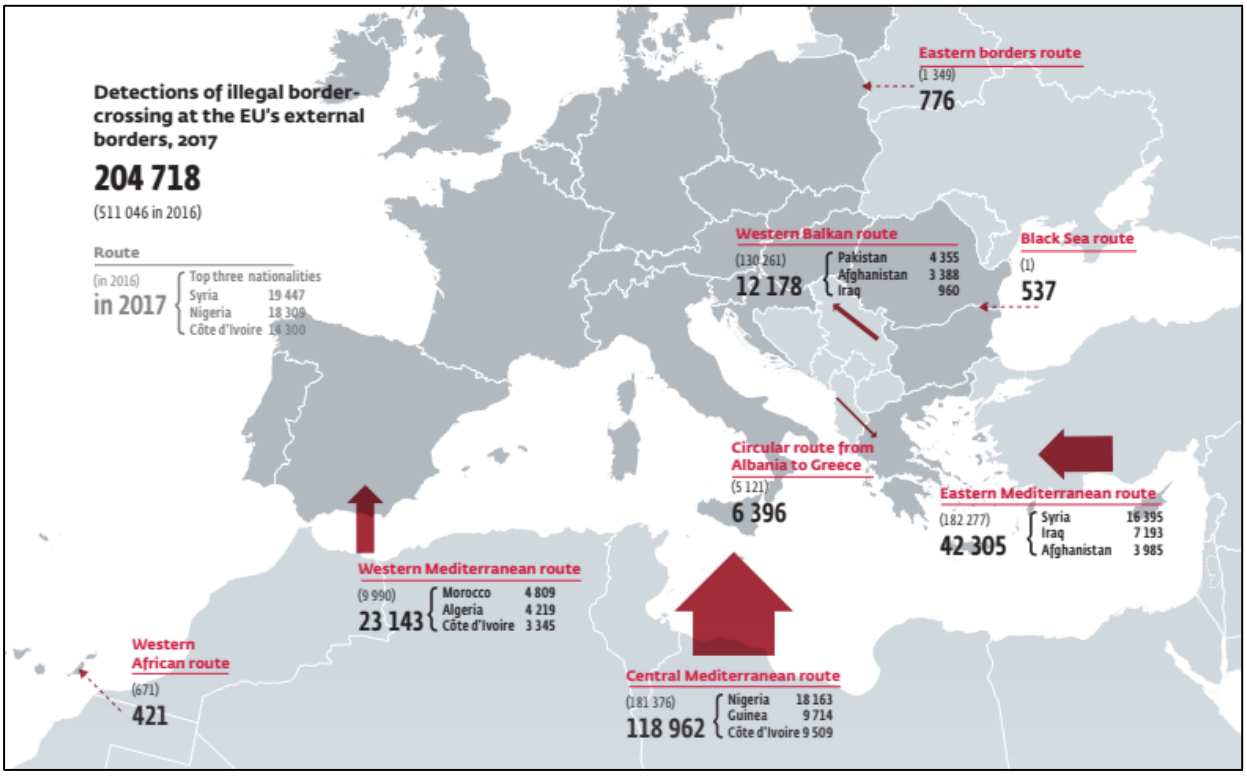

Figure 7 - Detections of illegal border crossing at the EU's external borders in 2017

Border control authorities are increasingly confronted with the detection of cross border crimes such as drug trafficking and the smuggling of excise goods, but also pollution and fisheries issues. While the synergies created offer opportunities, they also require adapting and scaling up of border control resources.

Terrorism is a threat that transcends borders, a global challenge that requires concerted effort. Initially the main conflict zones acted as areas of convergence, but during the last years the threat became more decentralised. As a consequence, the challenges of detecting terrorist movements are diverse and in all travel directions – on exit/entry and in-transit.

Formal border-crossing points offer authorities a structured environment for the potential identification of travelling terrorists or persons of interest. However, the green and blue borders pose many additional challenges, particularly during large and sustained irregular migration movements.

The graph below, created from data taken from the EU Terrorism Situation and Trend Report 2017[6] done by Europol, shows the number of attacks and of arrests from 2014 to 2016.

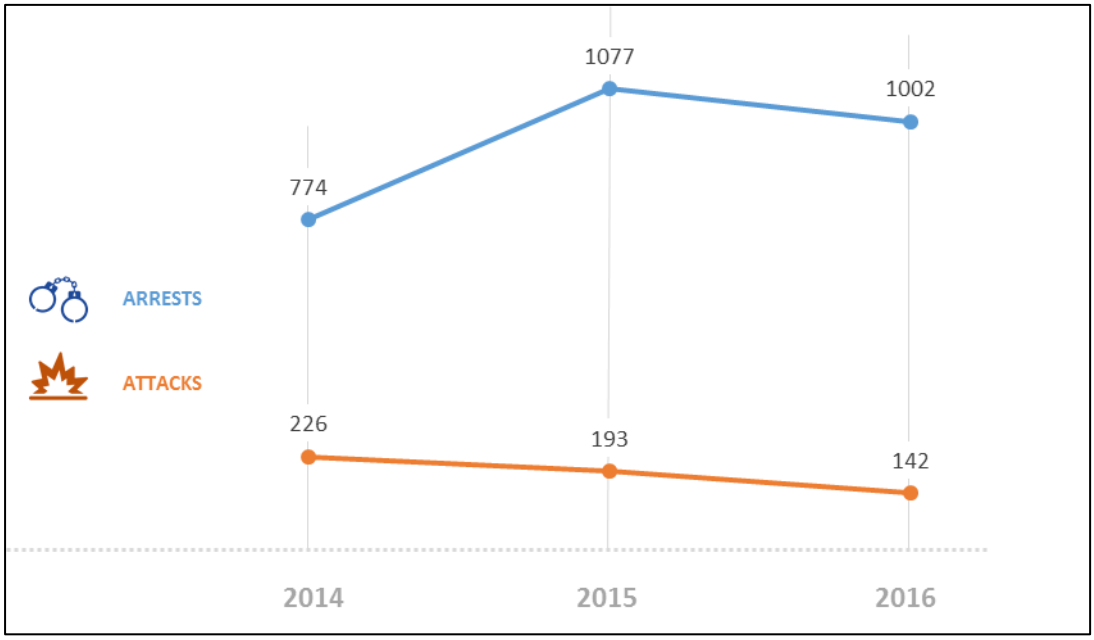

Figure 8 - Number of failed, foiled or completed attacks; number of arrested suspects 2014 to 2016

Borders provide challenges but also offer opportunities in better countering terrorism. The external border dimension is a geographical filter, where Member States (MS) can take actions, enforce the rule of law and pursue prosecutorial or judicial actions.

3.2 *Smart Management of Borders*

Effective management of the EU's external borders is essential if free movement within the EU is to function well. And to effectively patrol a coastline of almost 66,000 km and land borderline of more than 13,000 km modern technology comes into play.

Within the EU, Frontex[7] currently deploys European Border and Coast Guard teams[8], including a pool (provided by MS) of at least 1 500 border guards and other relevant staff to be deployed in rapid interventions (the pool can be deployed within five working days in a crisis situation). The agency also deploys vessels, aircraft, vehicles and other technical equipment provided by Member States in its operations. The equipment is acquired, leased or sometimes co-owned with EU Member States.

Probably the greatest advantage of technology is that it enables border patrol agencies to concentrate their resources: by deploying drones technology these agencies could benefit from a flexible tool that can adapt to changing circumstances and emerging threats.

Outlined in the Commission's European Defence Action Plan[9], the body believes EU funded research could help "support technologies for the development in Europe of Remotely Piloted

[6] https://www.europol.europa.eu/tesat/2017/

[7] Frontex is the European Border and Coast Guard Agency.

[8] Frontex also carries out air controls (in airports), but this task is not relevant in ROBORDER's context

[9] European Defence Action Plan 30.11.2016, downloadable here

Aircraft Systems (such as drones), as well as technologies to support the monitoring and security of EU borders."

A stronger European defence requires Member States' joint acquisition, development and retention of the full-spectrum of land, air, space and maritime capabilities. However, the European defence market suffers from fragmentation and insufficient industrial collaboration.

Some countries have begun considering buying drones but there is not a European joint initiative yet. A remarkable initiative is the one the EU undertook in 2016 in response to the migration crisis in the Mediterranean Sea: the European Maritime Safety Agency (EMSA) spent €76 million shopping for UAVs via two public tenders, drones destined to carryout border control and maritime surveillance and secure some of EU's sea frontiers.[10]

3.3 *Unmanned Aerial Vehicles (UAVs)*

Civil missions for a variety of tasks forces are an opportunity for drones to meet existing unmet needs. UAVs make it easier and more effective to conduct border security and maritime surveillance but also extends into providing the capability to prevent and add disaster relief with aerial view and monitoring. Other applications can be assistance to first response teams (primarily fire and police) in identifying civilians, gathering evidence, tracking fugitives, and assessing other safety hazards more immediately.[11]

The main advantage of this technology is that it allows:

- Collection of data from strategic points that have been inaccessible or too expensive to reach before
- Transport of urgently needed goods (with long-term aspiration to transport cargo and passengers)
- Monitoring of hazardous and dangerous situations without the requirement of pilots (reducing risks)

The outlook, according to a European study[12], is for nearly 60 000 UAVs by 2035 and 50 000 UAVs by 2050 with the decrease coming from the ability to leverage more complex systems centrally in replacing larger sets of drones "in-vehicle". Most of these units are expected to

Figure 9 - UAV used for search and rescue operation in the North Sea (Norfolk Area)

Figure 10 - Police UAV deployed by Abu Dhabi police to capture emergencies

[10] https://www.baltictimes.com/ and http://www.investigate-europe.eu/

[11] European Drones Outlook Study, SESAR Joint Undertaking, November 2016

[12] European Drones Outlook study, Published: 2017-04-21. Corporate author(s): SESAR Joint Undertaking

operate near or below 150 metres but yet fly beyond visual line of sight.

The opportunity to secure borders, perform maritime surveillance, and increase environmental protection will drive additional units, estimated to be under 1 000 in total. This estimate provides the capabilities to consistently cover EU borders including flying higher controlled borders daily, monition the coastlines every 2 days and having added capacity to also survey the Schengen borders every 5 days or to respond to environmental situations.[13]

The market is already starting to grow but in order for it to further take off, public acceptance and regulation regarding VLOS flights in populated areas will have to evolve. Uncertainly also regards technology advances in automatic flight capabilities (including but not limited to sense and avoid, improved energy sources for longer durations). This technical and regulatory uncertainty creates a set of scenarios around the demand outlook of UAVs in public safety & security, but even in a pessimistic scenario growth will be substantial.

[13] All estimates are taken from the European Drones Outlook Study

4 Market Analysis and Key Trends

4.1 *Target Market and Size*

The target market has been partially introduced already in the previous chapter. Nevertheless, the additional section in this chapter aims to provide a more quantitative overview of the existing market. In principle, the ROBORDER system targets to provide LEAs, military units and other international organisations with the capacity to monitor the borders, which could monitor their borders at relatively low total cost of ownership when compared to traditional border patrolling methods.

Though, official measures of actual current EU Member States' expenditure on similar border security systems is not available, nor other competitors are willing to share this information widely, just the EU allocation for border and visa strand for ISF (Internal Security Fund) is 2.76 billion euro. 0.25 per cent of EU's Multiannual Financial Framework is dedicated to ISF Borders and Visa. Police strand budget within the EU funding available, is another 1 billion euro[14]. On top of that, there is 9.26 billion of euro within the EU budget for home affairs allocated to asylum, migration and other financing, for instance for the relevant EU agencies, like Frontex.

Additionally, the Union has allocation of 0.55 billion euros for borders via Customs 2020 programme, and 1.7 billion is allocated for improving border security via H2020 framework programme for research and innovation. There are many cases of the EU external action funding tools' contribution to the MS various projects in support for border management strategies, law-enforcement capacities' improvement, and enhancement of the integrated border management overall. The contribution varies significantly, for example 4.47 million contribution to support capacity-building in order to enhance security of a country's land, sea and air borders[15].

However, as it appeared from research and also clarified by the European Court of Auditors, most expenditure for managing external borders is actually financed at a national level. Unfortunately, even as indicated in the European Court of Auditors' conclusion[16], the complete and reliable information on relevant national spending is not available.

Nevertheless, the proposal to set up a European Border and Coast Guard System could potentially contribute from ROBORDER system. The financial contribution for it is foreseen 238.7 million per year in 2016, and 31.5 million in 2017 for the purpose of tacking aforementioned tasks. The annual budget for 2020 is foreseen to be 322 million euro[17].

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[14] European Parliament, briefing on public expectations and EU policies "Protection of external borders", July 2016. Available online http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/586589/EPRS_BRI(2016)586589_EN.pdf

[15] See the specific example in the EP briefing "Protection of external borders", p. 3.

[16] European Court of Auditors, Special Report "The External Borders Fund has fostered financial solidarity but requires better measurement of results and needs to provide further EU added value", 2014, No. 15. Available online:

https://www.eca.europa.eu/Lists/ECADocuments/SR14_15/QJAB14015ENC.pdf

[17] EP briefing, p. 4.

Besides European Market, Gartner forecasts that worldwide security spending on security products and services will increase and reach 124 billion in 2019[18], which is 12.4 per cent more than in 2018. This relates to secure use of technology platforms, and in this regard is also relevant to ROBORDER. Additionally, according to Statista study[19], the size of the global video surveillance market in 2023 is going to reach 62.62 billion U.S. dollars, in comparison to roughly spent 30.18 billion in 2017. The other unmanned vehicles market trends are presented in the other parts of the following chapter.

To conclude, it is clear to forecast that potential for ROBORDER success is high and there is market place for its operation, even within the EU, and regardless the EU MS existing funding on top of that. However, as unfortunately, it has been experienced also by European Court of Auditors, the exact expenditure statistics are not available on the national level.

4.2 *Key Trends*

This section presents the key trends identified from the end users' point of view. Additionally, it covers the results of the end-users survey and the importance and value proposition of the ROBORDER system for the users.

4.2.1 High-level user needs

The significance of border security among EU Member States' security strategies has increased as a consequence of the rise in heterogeneity of threats (such as illegal trafficking, illegal migration and terrorism), which added up to the strain already posed by the sheer size and diversity of terrain, adverse weather conditions and other environmental factors.

Within this problem formulation, border authorities require technologies that:

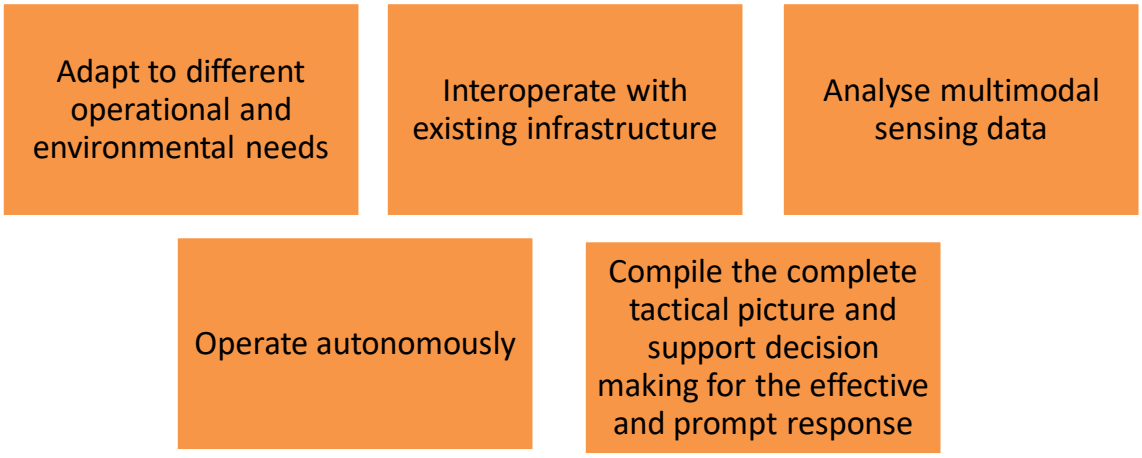

Figure 11 – The ROBORDER required technologies

[18] Gartner, press release, "Gartner Forecasts Worldwide Information Security Spending to Exceed $124 Billion in 2019". See online https://www.gartner.com/en/newsroom/press-releases/2018-08-15-gartner-forecasts-worldwide-information-security-spending-to-exceed-124-billion-in-2019

[19] Statista, "Size of the global video surveillance market in 2016, 2017 and 2023", available online https://www.statista.com/statistics/864838/video-surveillance-market-size-worldwide/

4.2.2 The results of the ROBORDER end-users' needs survey

The questionnaire aims at collecting end users (Border Police, National Guard or other border forces members or ROBORDER consortium) opinions about the concept and the added value the system would bring to their regular activities.

It is structured in 3 sections: background information, border security and general questions:

- The background questions simply serve to identify the partner who is responding plus other general information such as the home country and their role.
- Questions in the border security section are grouped by innovation objectives (IO) of the project; they try to assess which challenges users are currently facing in their work, how they face them, and they ask for their opinion on what ROBORDER offers to solve those challenges.
- The last section objective is to assess the perceived added value of ROBORDER among users: why would they chose ROBORDER instead of another system, what are ROBORDER weaknesses and what would be an acceptable price for the system as well.

The answers provided have been than analysed in order to figure out per every single category the most important piece of information that could be beneficial for the continuation of the project.

The IO1 is oriented towards adaptable sensing, robotics and communication technologies for different operational and environmental needs. Majority of the Member States' responsibles have identified that heterogeneity of terrain is one of the main problems for the protection of the state's borders. EU countries also face difficulties due to extension and typology of borders. Such factors as winds, seas, the ocean, mountains and particular flora can make the border surveillance extremely difficult. Thus, a mix of different technologies, personnel and equipment has to be applied in order to overcome such weaknesses.

Unmanned systems, which could be one of the main solutions for difficult weather conditions, unfortunately, are not widely spread in the European Union Member States. Only very few MS are equipped with long range surveillance systems and provide a surveillance equipment for pedestrian patrols.

In order to address these challenges, ROBORDER system with its fleet of unmanned vehicles might be a useful solution. Some potential ROBORDER end users identified that ROBORDER could help border and coastal guards to accomplish everyday activities and tasks. As some end users noted, the procedures should not be automated, but fleets of unmanned vehicles could bring critical information as videos, alerts or images from the area of interest, like mountainous or windy ocean shore, to the place, where the decisions are taking place.

Additional value of ROBORDER could come from the environmental reasons. At the moment, there is no information available about environmental disasters, like pollution incidents, and even more no specific technology, which could be supporting the officers in the detection of such incidents.

The most used techniques for the identification and tracking of illegal activities are still thermal cameras, night vision equipment, radars and video surveillance. Some have even video analytics for automated detection and alarming to command and control centre, others identify illegal activities by video and image tracking using conventional deep learning tools.

ROBORDER as a system could present a great level of improvement in terms of performance of the tools, level of integration with existing procedures and others. As detection and identification are the basis for analytics, the accurate data collection as much

as possible in real time facilitates quicker decision making and reduces false alarms and useless dispatch of border patrols, increasing efficiency of border surveillance.

Majority of the survey respondents also expect that ROBORDER detection and identification capabilities can strongly improve the quality of their analysis and provide a better situational awareness picture.

5 Key Resources: Hardware

The ROBORDER project aims at integrating ground-breaking technologies towards the delivery of a fully functional autonomous surveillance system of remotely controlled single or swarms of unmanned vehicles (including UAV, USV, UUV and UGV) which will incorporate multimodal sensors as part of an interoperable network to detect, assess and respond to hazardous situations in border surveillance missions and tasks.

The great number of technologies used by the ROBORDER system can be grouped in 4 main classes: unmanned platforms, manned platforms, sensors and hardware/software modules. In the section, each one of those groups and its relevant technologies will be briefly presented. This section provides first answers to the key resources questions (See Figure 7) in the ROBORDER Sustainability Framework.

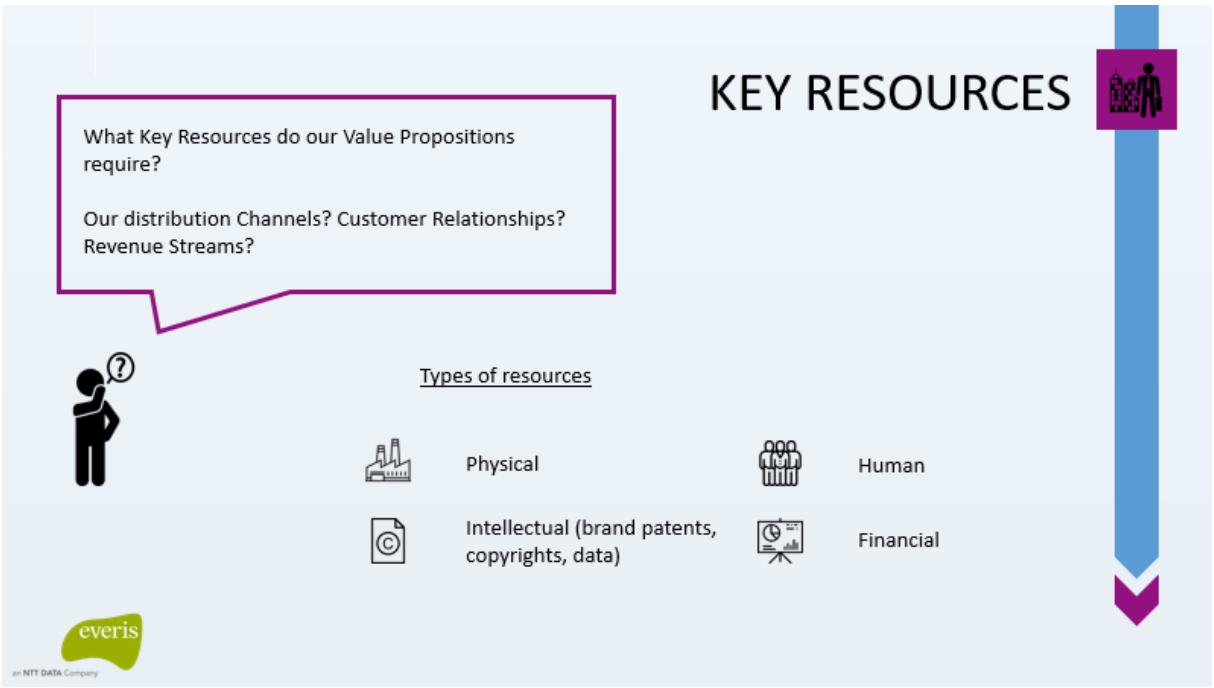

Figure 12 – Key Resources Overview from ROBORDER Sustainability Framework

5.1 *Unmanned platforms*[20]

5.1.1 Unmanned aerial vehicles (UAV)

An UAV is an aircraft with no pilot on board which can be controlled remotely (e.g. flown by a pilot at a ground control station) or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems.

There are several categories of UAVs, depending on the type mission they are used for (target and decoy, reconnaissance, combat, logistics, research and development**,** civil and commercial), but UAVs can also be classified in terms of range/altitude or weight.[21]

5.1.2 Unmanned ground vehicles (UGV)

UGVs are a land-based counterpart to UAVs vehicles, it therefore operates while in contact with the ground and without an onboard human presence. Generally, the vehicle has a set of sensors to observe the environment and will either autonomously make decisions about its behaviour or pass the information to a human operator at a different location who will control the vehicle through tele-operation.

UGVs can be used for many applications where it may be inconvenient, dangerous, or impossible to have a human operator present. Most of UGVs are used in military, civil and commercial or emergency response situations (a few are also used in space e.g. NASA exploration vehicles).[22]

Figure 13 - Robotnik Guardian Standard version (UGV)

Figure 14 - Tekever AR-3 Net Ray (UAV)

5.1.3 Unmanned surface vehicles (USV)

USV are vehicles that operate on the surface of the water without a crew and, like UGVs and UAVs, they can be either piloted remotely (by an operator located on land or on board of another vessel) or operate independently.

USVs are valuable in oceanography and more in general in hydrographic survey, as they are more capable than moored or drifting weather buoys, cheaper than the equivalent weather ships and research vessels and more flexible than commercial-ship contributions. Other

[20] All photos showed in this chapter are taken from the technological roadmap or from the websites of the respective consortium members

[21] https://www.theuav.com/, https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle

[22] https://en.wikipedia.org/wiki/Unmanned_ground_vehicle

applications include military missions, vehicle/animals detection or tracking, harbour and coastal surveillance.[23]

5.1.4 Unmanned underwater vehicles (UUV)

UUVs are any vehicles that are able to operate underwater without a human occupant. These vehicles may be divided into two categories, autonomous underwater vehicles (AUVs), which operate independently of direct human input and remotely operated underwater vehicles (ROVs), which are controlled by a remote human operator and tethered by an armoured umbilical cable that carries electric power, video and data.

The navies of multiple countries are using UUVs in oceanic warfare to discover and terminate underwater mines, but UUVs also have several extra military applications, such as ship hull inspection, nuclear reactor decontamination, exploration, and mining/drilling.[24]

Figure 16 - Unmanned Surface Vehicle (USV)

Figure 15 - OceanScan LAUV (UUV)

5.2 *Manned platforms*

ROBORDER system will heavily rely on unmanned platforms, but a few manned platforms are also planned to be used for different purposes. Those platforms include:

Light aircrafts like the Fraunhofer Dolphin (see picture below) will be used as platform carrier, but mainly for testing purposes of radar systems developed within the ROBORDER project

Four-wheel vehicles like the Elettronica MUROS (see picture below) which will serve as mobile lab to be used in trials and for data collection.

Figure 18 - Fraunhofer Dolphin

Figure 17 - Elettronica MUROS vehicle

[23] https://www.shockmitigationdirectory.com/earticle-detail/unmanned-surface-vehicles---usvs-go-from-concept-to-service/27/ , https://en.wikipedia.org/wiki/Unmanned_surface_vehicle, http://www.unmannedsystemstechnology.com/company/autonomous-surface-vehicles-ltd/

[24] https://en.wikipedia.org/wiki/Unmanned_underwater_vehicle , http://www.fdot.gov/planning/statistics/fav/2015summit/Session5-Ellenrieder.pdf

5.3 *Sensors*

Several multimodal sensors, as part of an interoperable network, are one of the key technologies on which the ROBORDER system relies on. The network will include enhanced static networked sensors such as border surveillance radars, as well as mobile sensors customised and installed on board unmanned vehicles. These will include:

- Passive radars on board of UAVs and USVs that can extend the capabilities of the existing border surveillance radars. All radars will be optimised for a variety of operational conditions and will be network interoperable with existing infrastructure.
- Passive RF-signal sensing devices on board unmanned platforms. By intercepting emission sources that are present in area, they enrich the overall situational awareness picture with this information, allowing for further characterizing the nature and behaviour of entities in the picture, and detecting unauthorized signal sources
- Other mobile sensors like thermal cameras (infra-red) optical cameras, EO[25] systems and FMCW[26] rotating radars.

5.4 *Vendors*

In this section an overview of the main vendors (in terms of hardware, hence unmanned/manned platforms and sensors) present in the market will be provided. Given the great variety of platform already present in the marketplace, this analysis is focused only on the ones with applications in the homeland security area.

5.4.1 UxVs

As we saw in the context chapter, the unmanned vehicles market has boomed in the few pas years. In the market there is a great variety of UAVs manufactures, both small and big companies started producing and selling a great variety of technologies for different uses. In this section we will present some of the main UxVs vendors, the technologies they offer and their application (in terms of sector of activity and type of mission).

Despite a great number of small sized companies in the market, the main players remain the very big companies (the defence contractors analysed in section 6, such as Airbus, Leonardo, Lockheed Martin and IAI) and some large-medium sized American, Chinese and European (mainly French and German) companies specialised in unmanned systems (Precision Hawk, Blue Bird Aero Systems, EMT Penzberg, DJI, Ehang).

In terms of sector of activity, UxVs applications are mainly in the defence (for the big contractors mentioned beforehand), security and commercial sector (typical sectors for almost any vendors are agriculture, mining and quarrying, energy, oil & gas, industrial facilities and infrastructures). Around a quarter of the vendors analysed also manufacture UAVs for leisure activities and to professionals of video or photo making. When it comes to homeland security and border patrol, only a few vendors produce UxVs explicitly for this specific sector (for example Hoverfly, Blue Bird Aero Systems, EMT Penzberg, Precision Hawk [27] and Ehang).

[25] electro-optical

[26] Frequency Modulated Continuous Wave (FMCW)

[27] See as an example: https://www.precisionhawk.com/government

Missions performed by the UAVs include surveying & mapping, tracking, search & rescue, inspection, surveillance, filming and even delivering. When it comes to the defence sector, all missions are military related (ISR, communications, general support to operations, surveillance and threat detection).

Concerning the type of unmanned systems, UASs remains by far the most present in the market, followed by UGVs, USVs and UUVs, which are not yet as "popular".

5.4.2 Manned platforms

As one can imagine, there is a huge number of different manned platform for a lot of different used in the market. Obviously, this analysis only focuses on the platforms which are foreseen to be used with ROBORDER platform, which are light aircrafts used as platform carrier and four-wheel vehicles used as mobile lab for trials and for data collection.

An ultralight aircraft refers to a class of lightweight aircraft usually consisting of 1 or 2 seat capacity and with a fixed wing[28]. The world of ultralight aircraft has recently become more affordable and achievable, both for recreation and commercial activities. Ultralight flying in Europe doesn't feature so much on EASA regulations, but in general national laws in MS don't differ too much, as the ICAO's Standards and Recommended Practices for Use of Ultralight Motorized Airplanes (ULM) are mostly followed by the Member States.[29]

Key players of the ultralight aircraft market include many European companies such as Costruzioni Aeronautiche Tecnam S.R.L., Flight Design GmbH, Pipistrel, Evektor and P&M Aviation. There is also a remarkable competitions coming from the US (Cub Crafters Inc., Quicksilver Aircraft, American Legend Aircraft Co.) and from emerging markets such as China, India and the U.A.E.

5.4.3 Sensors

ROBORDER system is planning to integrate a great variety of sensors, in this section we will provide an overview of the vendors' landscape for passive radars, passive RF-signal sensing devices and a few more mobile sensors.

The passive radars market and the passive RF-signal sensing devices market are dominated by the big multinational companies in the defence and security market, the same we already mentioned several time in this market analysis (Indra, Lockheed Martin, Raytheon, Thales, BAE, ELTA Systems, Airbus, Leonardo etc.). However, this is a fast growing market and new competitors are entering the market particularly in defence and homeland security.

The aerospace and defence industry holds the largest share of the thermal imaging and other mobile sensors market, key players include the big defence contractors and their subsidiaries but also some smaller companies who are specialised in those particular technologies (Flir Systems, Xenics, Seek Thermal, Thermoteknix Systems, C-Thermal, Intro). Like for many others technologies, increasing competition from the Chinese market, amongst others, can be registered.

[28] https://ul-center.com/2016/03/09/ultralight-flying-in-east-europe-rules-regulations-and-other-important-information/

[29] https://www.icao.int/assembly-archive/Session26/A.26.WP.57.ADD.1.P.EN.pdf

6 Key Resources: Software

ROBORDER is first of all a system which is equipped with adaptable sensing and robotic technologies; the software part is essential in order to allow all other components to successfully interoperate. The system architecture is one of the strengths of ROBORDER, end-users will dispose of an intelligent holistic solution providing all different hardware and software functionalities.

Software includes not only the general architecture of the platform, but also many other modules for flight simulations and recording, UxVs' communication protocols, command and control of the sensors, data processing and decision support, computer vision algorithms. In this section an overview of the software components of ROBORDER system will be provided.

6.1 *Software modules*

A great number of modules brought by consortium partners are planned to be used within the scope of ROBORDER, those modules can be classified according to their purpose:

- Communication with UxVs

SDR platforms[30] like GAMALINK (developed by TEKEVER) to be used for the development of the RF signal sensor to be used on board of UxVs but also cloud-based architecture for message delivery.

- Sensors and data sharing control

Software modules like the Scout C2 SW (Elettronica GmbH) for the command and control of the sensors network, monitoring; control platforms capable of integrating, aggregating and elaborating information coming from multiple sources (e.g. MONICA, Monitoring and control architecture developed by APL and CNIT)

- Detection and recognition of illegal activities

Software tools like video analysis modules and computer vision algorithms for tracking cyber and cyber-physical attacks (based on recognition of human activity) but also for detection of pollution incidents. For example the Video content analysis module owned by CERTH and MKLAB.

- Simulations and augmented reality

Set of tools for simulation purposes lie the Synthetic Environment developed by TEKEVER, but also augmented reality toolkits for human robot interface (e.g. ALVAR toolkit/SDK of VTT)

- Specific languages for UxVs missions

Domain specific languages like the one owned by the University of Athens, which are used to describe UxV missions for border security operations (ROBORDER scenarios)

- Ontology models and repositories

Models used for population and semantic enrichment of ROBORDER ontology models as well as for storing them and performing queries and reasoning. This

[30] Software defined radios (SDR)

includes an ontological model for the semantic representation of CISE data model, as well as a domain ontology for the second version of the Common Integrated Risk Analysis Model (CIRAM 2.0).

- Optimal Area Surveillance and Autonomous Swarm Navigation

The key element of the fully functional ROBORDER system/methodology (called the Mission Resource Controller) is an optimal resource management and planning algorithm – abbreviated also in literature as Parameterised Cognitive Adaptive Optimisation PCAO. The Resource Controller, developed by CERTH-ConvCAO group, will be firstly tailored and modified to be applicable to the problem of autonomous navigation of UxV swarms for optimal border surveillance.

6.2 *Vendors*

Each one of the software modules just presented would need a specific vendor analysis. However, in this chapter we will only provide a short and global overview.

Some of the key players in the defence and security sector also provide software services for communications, data sharing, threat detection and simulations. In comparison with the hardware market, a good number of those big companies rely on other contractors: those include software companies like Dassault Systems and PTC (formerly Parametric Technology Corporation) but also SAP and Microsoft, which are major players in other sectors as well.

Other vendors worth mentioning are Ettus Research, world's leading supplier of software defined radio (SDR) platforms, General Dynamics, Systematic, Honeywell, Cisco Systems and the main players coming from eastern markets (ZTE Corporation and Huawei from China and HTL Technologies from India).

7 Competitor Analysis

In order to understand our customers, we analysed how the market is working. The analysis of the main competitors in the market have provided important insights on how the customers could be distributed, and where ROBORDER could position itself.

The competitive landscape analysis is a crucial part of the research and planning phase for ROBORDER. The importance of this step is given by the fact that it helps identifying their strengths and weaknesses and it provides a valid starting point for developing an effective strategy in the border security market.

The major players in the border security market have been analysed, great majority of the identified competitors are big multinational companies: defence and security contractors, key players in the space and aerospace market and high-tech companies.

Most of the competitors are involved in the research, design, development, manufacture, integration and sustainment of defence and security solutions, both hardware and software. In this section the most relevant competitors will be presented one by one, there will also be a concluding chapter summarising the main findings and key takeaways.

7.1 *Airbus Group*

Leader in aeronautics, space and related services. Specialties: Aerospace, Defence, Space, Innovation, Cyber Security, IT, Engineering.

Defence and security sector

Airbus designs, develops and manufactures military aircraft but also offers a broad range of services to fully support its customers (secure communication platforms, digital services for defence and cyber security applications)

Security solutions[31] include:

- Maritime Safety & Security (VTS, CSS, CIP[32]- ports, coastal surveillance, offshore protection)
- Integrated Security Solutions (Actacor® capability pillars: ActaSense[33], ActaLead[34], ActaAct[35]) implemented in several counties (see the figure below on the next page)

Unmanned Aircraft Systems (UAS)

Airbus provides a wide range of UAS solutions for military and commercial applications. The company's heritage in manned flight is leveraged to supply robust and dependable UAS.

[31] http://www.airbus.com/defence/security-solutions.html

[32] Vessel Traffic Service (VTS), Channel Ship Services (CSS), Critical infrastructure protection (CIP)

[33] http://www.airbus.com/content/dam/channel-specific/website-/products-and-services/defence/security-solutions/airbus-security-solutions-actasense.pdf

[34] http://www.airbus.com/content/dam/channel-specific/website-/products-and-services/defence/security-solutions/airbus-defence-and-space-security-solutions-actalead.jpg

[35] http://www.airbus.com/content/dam/channel-specific/website-/products-and-services/defence/security-solutions/airbus-defence-and-space-security-solutions-actaact.jpg

Airbus has supported military forces for nearly a decade and its systems have been deployed for missions in such combat zones as Afghanistan and Mali.

Here follows a list of examples of UAS solutions:

- European UAS, long-endurance aerial UAV system designed for surveillance, reconnaissance and target acquisition
- Harfang, a Medium Altitude Long Endurance UAS for joint armed forces able to fulfil a wide range of missions, from surveillance to sensitive peacekeeping
- ATLANTE, Tactical Unmanned Aerial System ensuring intelligence, surveillance and reconnaissance missions by day and night for ground forces deployed in theatre
- Mini-UAVs (developed by subsidiary SURVEY Copter), flying computers for surveillance
- KZO, a tactical UAS with a powerful engine suited for high speed reconnaissance missions. The gathered information is immediately available and can quickly be distributed in the command structure
- Zephyr, a High Altitude Pseudo-Satellite (HAPS) that fills a capability gap between satellites and UAVs as it runs exclusively on solar power and it flies above the weather and above commercial air traffic

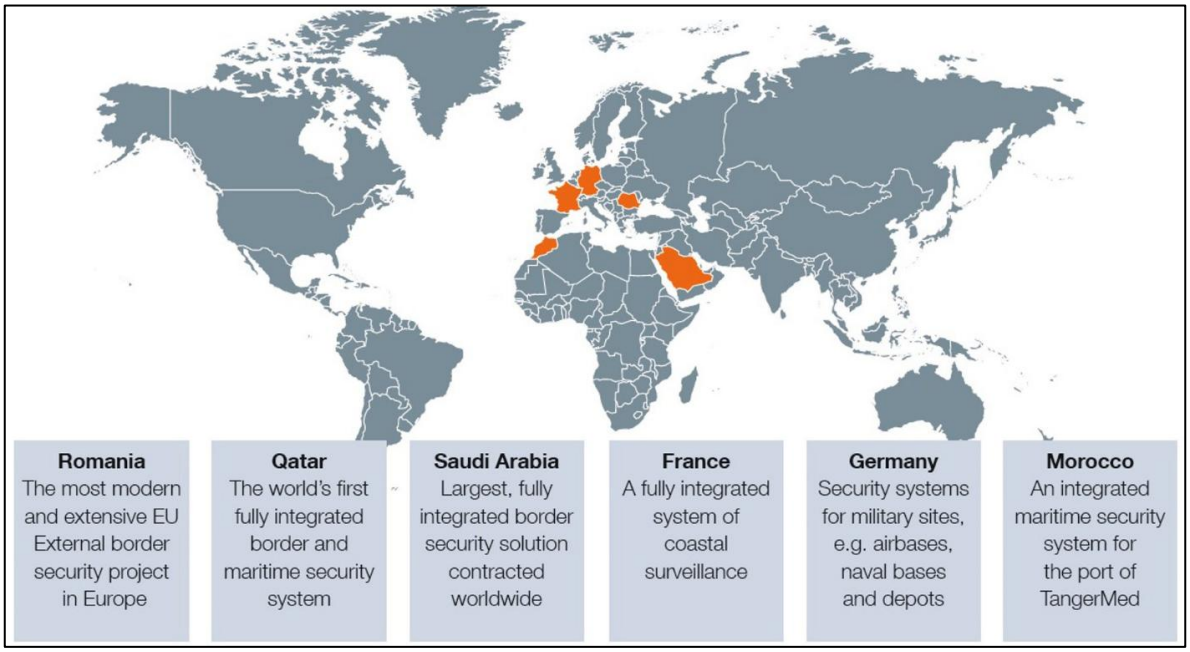

Figure 19 - Actacor® solution world implementation

7.2 *Leonardo*

Global high-tech company and key players in Aerospace, Defence and Security.

Defence systems[36]

Land and naval weapon systems, underwater systems (weapons, sonar systems, for surveillance) and unmanned systems[37] (surveillance and tactical patrolling. Some UGVs, one naval platform and a prototype of a UUV)

Land & Naval defence electronics (military)

Land: wide portfolio of advanced and multifunctional surveillance radars, in-vehicle radars, control systems (digital battlefield systems, detection and location of entities, generation and sharing of situational awareness, digital-aided coordination of airborne, naval or artillery forces).

Naval: combat systems for any type of vessel (communication systems, navigation systems, radars as well as UAVs)

Leonardo provides a Military Systems for Border, Territory & Maritime Control (both on land and sea)[38] integrations state-of-the-art technologies in the field of surveillance and C4I (near-real-time sharing of tactical information between platforms and command posts, "virtual fences" integrated with mobile surveillance systems and unmanned aircrafts).

The offer is organised in 2 domains:

- Integrated Systems for Border & Territory Control

Integrates specialized sensors such as Ground Surveillance and Passive Radars, short to long range Thermal Imaging cameras and day/night multi sensor systems, Acoustic systems and solutions for Mobile Situational Awareness, Fire Control and Blue Force Tracking.

- Integrated Systems for Maritime & Coastal Surveillance

Command and control solution aimed at collecting, fusing and analysing data from multiple sources (the system builds and share a comprehensive operational picture with different agencies and organizations). This type of systems also exploits long range coastal radars with Over the Horizon capabilities.

Customers include the Italian Navy, North Africa, Canadian Border Control Authorities and Thailand.

Airborne & Space systems[39]

Wide range of products and solutions for aircraft platforms that include integrated mission systems, airborne radars and sensors, electronic warfare systems, on-board avionics, aerial target systems and simulation systems. Also develops and produces Remotely Piloted Aircraft Systems (RPAS).

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[36] http://www.leonardocompany.com/product-services/sistemi-difesa-defence-systems-3

[37] http://www.leonardocompany.com/en/product-services/sistemi-difesa-defence-systems-3/sistemi-pilotaggio-remoto-unmanned-systems

[38] http://www.leonardocompany.com/documents/63265270/75096213/body_Border_Control_LQ_mm08482_.pdf

[39] http://www.leonardocompany.com/en/product-services/sistemi-avionici-spaziali-airborne-space-systems-2

Customer is provided with solutions for reconnaissance, surveillance, target acquisition and recognition ISTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance), based on integrated and agnostic architectures, i.e., capable of operating on any platform and with any on-board equipment to ensure a constant situational awareness at the tactical level and interoperability with any other operational environment Security & Information Systems.

Involvement in EU projects:

Leonardo is consortium member of the Tensor EU project[40], which aims at developing a platform offering Law Enforcement Agencies fast and reliable planning and prevention functionalities for the early detection of terrorist activities, radicalisation and recruitment.

7.3 *Indra*

Global provider of solutions in specific segments of the Transport and Defence markets, leader in developing end-to-end technology solutions in the Defence and Security field and many others.

Air traffic industry:[41]

Advanced automated air traffic control systems (over 300 installations worldwide), one of the leading companies in the SESAR program (Single European Sky), have deployed several network of radars that provide air traffic surveillance.

Defence industry:[42]

Different systems designed to customer specifications (civil and military) which fulfil the operational requirements of all environments (land, sea, and air). Also offer a full range of training solutions.

At ground defence level Indra installed over 5,700 km of borders that are guarded by our technology (see security section below). Additionally, they designed CBRN (Chemical, Biological, Radiological and Nuclear) vehicles to detect and identify chemical, biological, radiological, nuclear and explosives threats. With regard to the sea, their technology provides an effective response in the most adverse environments, developed combined antenna system for submarines which enables radar and communication signal intelligence tasks to be carried out simultaneously. In the space sector they participate in the Galileo program

Ports industry:[43]

Provide solutions that offer technological support for the complete range of port infrastructure processes, design and implement systems to prevent and minimize the damage caused by floods and droughts.

Offer their own solution called iMARE®: manage logistics, assist port authorities, port managers/operators and other agents in managing stopovers, VTMS (Vessel Traffic Management System) solutions with a number of sensors and FAMS systems.

[40] http://www.tensor-project.eu/

[41] https://www.indracompany.com/sites/default/files/170227-brochure_01_atm_general_eng_-_digital_v6.3.pdf

[42] https://www.indracompany.com/sites/default/files/ds_triptico_v18_02_en_b_hoja.pdf

[43] https://www.indracompany.com/en/port-operations-logistics-imarer-suite

Security industry:

Comprehensive security and cybersecurity services, ICT/IC security

Surveillance and border protection[44]: Protection of all kinds of borders (land, sea, river and offshore platforms), flexible solution adapted to client needs and system requirements, use of MRI (magnetic resonance imaging) surveillance aircraft, radars, advanced sensors and other technologies.

Integrated border surveillance system[45] (deployed in Spain, Hong Kong, Latvia, Romania, Portugal, Bulgaria and Poland), coastal surveillance systems (CSS)[46] (deployed in Spain, Hong Kong, Latvia, Romania, and Portugal).

7.4 *Thales*

Multinational group, designs and builds electrical systems and provides services for the aerospace, space, defence, transportation and security markets.

Aerospace:

Air traffic management solutions (TopSky - ATM Solution[47], one the most used in the world), navigation aids, surveillance (radar and non-radar technologies) and other solutions (trainings)

Defence:

- Communications, command and control systems
- Mission services and support
- Protection and mission / combat systems
- Surveillance, detection and intelligence systems
- Training & Simulation

Force Protection and Border surveillance[48] system allow users to monitor borderlines, improve reaction time from detection to interception, match the diverse nature and level of threats, and optimise the way the different human and technical resources are deployed. Examples of such systems are:

- MobIDS, perimetric protection system (Germany)
- DISCUS, security system to support the Netherlands Armed Forces deployed in Afghanistan
- SPECTRE, assessment study and demonstrator dedicated to platoon and camp protection (France)

Thales also produces unmanned aerial vehicles systems for long-term surveillance (both military and civil applications).

[44] https://www.indracompany.com/en/surveillance-border-protection

[45] https://www.indracompany.com/sites/default/files/indra_integrated_border_surveillance_systems_0.pdf

[46] https://www.indracompany.com/sites/default/files/indra_css_coastal_surveillance_systems_v0916_baja.pdf

[47] https://www.thalesgroup.com/en/global/activities/aerospace/air-traffic-management/automation

[48] https://www.thalesgroup.com/en/global/activities/defence/land-forces/force-protection-and-border-surveillance

Security:

Many sectors including state security and border surveillance[49]. Examples of applications:

- In a North African country, Thales has deployed a network of cameras and sensors connected to control centres located inside the country, to ensure the reinforced security of a 1000-kilometer border.
- In France, 210 Spy Ranger mini-UAVs will assist the French army to remotely scan the land within a 30 kilometre radius.
- In Spain, 4 Gecko cameras developed by Thales were mounted on vehicles, allowing for an optimal visibility on specific spots of land.

Involvement in EU projects:

Thales is a consortium member of different EU project such as the Tensor project[50] (platform offering LEAs fast and reliable planning and prevention functionalities for the early detection of terrorist activities, radicalisation and recruitment) and the Bodega project[51] (future border checks with human factors expertise in order to enhance efficiency, border security and traveller satisfaction).

7.5 *Elbit Systems*

International high-technology company engaged in a wide range of defence, homeland security and commercial programs.

Several lines of business, here's the most relevant for Roborder market research

Homeland Security Systems[52]

Development, manufacturing, delivery and installation of security solutions, including: long, medium and short range day-night surveillance sensors, surveillance vehicles with EO sensors and radars, small UAS, electronic and fibre-optic intrusion detection fences, security C4I centres, IP security surveillance networks management.

Systems suitable for border security, coastal surveillance security systems, airport security systems, perimeter security (Large sites & border areas), transportation security, pipeline security systems.

They implemented a system of Integrated Fixed Towers (IFT) for border security in the US and they also do border control for Israel.

UAS, USV and UGV[53]

Elbit systems offers a comprehensive range of UAS, in service with numerous military and security forces worldwide.

[49] https://www.thalesgroup.com/en/worldwide/security/border-surveillance-and-security

[50] https://tensor-project.eu/

[51] http://bodega-project.eu/

[52] http://elbitsystems.com/products/homeland-security-systems/

[53] http://elbitsystems.com/products/uas/

One example is the Seagull USV for end-to-end mine hunting operations, including detection, classification, location, identification and neutralization of bottom, moored and drifting sea mines while taking the sailor out of the mine field.

The company also produces a particular UGV (called UT30MK2[54]), an unmanned turret for military applications.

7.6 *L3 Technologies*

Leading provider of a broad range of communication, electronic and sensor systems used on military, homeland security and commercial platforms. Also prime contractor in aerospace systems, security and detection systems, and pilot training.

Electronic Systems

Aviation Communication & Surveillance Systems, ACSS (joint venture with Thales)

- Maritime systems: automatic identification systems (AIS), communication products, control system equipment, monitoring systems and navigation products
- Security and detection systems for aviation, transportation, government and critical infrastructure: Advanced Personnel Screening, Aviation Checkpoint Screening, Explosives Detection Systems, Explosives and Drug Trace Detection, Metal Detectors, X-ray Screening Systems, Ports & Borders Screening Systems (X-ray screening systems and sensors used in border checkpoints, ports and on the move)
- Unmanned systems: Delivering products, systems and services for a variety of customers and applications. The Airborne Pursuit & Exploitation (APEX) is an electrically powered, small tactical unmanned aircraft system designed to support a variety of mission applications including border patrol and homeland security[55]

Aerospace Systems

Aerospace Systems delivers integrated solutions for the global ISR (Intelligence, Surveillance, and Reconnaissance) market and provides modernization, upgrade, sustainment, and maintenance and logistics support for a wide variety of aircraft and ground systems.

Communication Systems

Advanced and broadband communications systems.

Sensor Systems

Provide a broad range of multi-domain ISR mission solutions, including space avionics and payloads, soldier systems, airborne sensors, special mission command & control, intelligence solutions, modelling & simulation, and life-cycle support. They offer both maritime and ground sensor systems.

[54] http://elbitsystems.com/products/land-systems/unmanned-turret/

[55] http://www2.l3t.com/uas/products/r_apex.htm

7.7 *Lockheed Martin*

Global security and aerospace company principally engaged in the research, design, development, manufacture, integration and sustainment of advanced technology systems, products and services.

Aerospace & Defence

Aircrafts, Ground vehicles, naval systems, tactical communication, radar systems (radar and electro-optical/infrared sensor systems providing advanced precision targeting, navigation, threat detection and next generation intelligence, surveillance and reconnaissance capabilities)

Autonomous and unmanned systems: military, civil and commercial. Air land and sea systems.
VCSi, Modular Unmanned Vehicle Control Software [56]

Information Technology

Builds and delivers a full spectrum cyber capabilities supporting the offensive and defensive efforts of customers.

Space

Builds the technology to explore the solar system, predict the weather, deliver precise GPS, detect and defeat missile launches.

Emerging Technologies

Advanced Aeronautics, Nanotechnology, Robotics, Scientific Discovery, Advanced Manufacturing, Quantum.

7.8 *Raytheon*

Technology and innovation leader specializing in defence, civil government and cybersecurity solutions.

Missile defence, Command and control, Sensors and imaging, Cyber, Electronic warfare, Precision weapons, Training, Mission support, Innovations.

Sensor and imaging[57]

Raytheon offers a great variety of radars, ground air and maritime surveillance, Electro-optical/infrared sensors, Space based sensors, radio frequency sensors, sonar and acoustic sensors, unmanned aircraft systems (serving both government and commercial customers).

Command and control[58]

Offers integrated systems, battle control, air traffic solutions, communications, data encryption, weather information and avionics.

[56] https://www.lockheedmartin.com/us/products/cdl-systems/VCSi.html

[57] https://www.raytheon.com/index.php/capabilities/sensors

[58] https://www.raytheon.com/capabilities/command

7.9 *Textron*

Global aerospace, defence, security and advanced technologies industrial conglomerate

Bell

Producer of commercial and military, manned and unmanned aircraft.

Textron Aviation

General aviation: range of products include business jets, turboprops, piston engine aircraft and military aircraft.

Industrial

Several brands from Industrial businesses.

Textron Systems[59]

Develop and integrate products, services and support for customer missions including defence, homeland security, aerospace, and infrastructure protection:

- Unmanned systems

Multi-mission unmanned aircraft and surface systems (missions: aerial survey & geospatial analysis, disaster response, critical infrastructure security, intelligence, surveillance & reconnaissance, border security)

- Border security systems[60]:

Three main functionalities:

1. Search (identify areas of vulnerability through geospatial imagery analysis and fusion of Intel reporting)
2. Verify (layered ISR capabilities allow for tipping and queuing of assets. Based on UAV feeds and fusion of multi-INT reporting, queue additional aerial assets to verify the threat)
3. Respond (With real-time situational awareness leaders can deploy response teams with precision to neutralize any threat)

Examples: Shadow® v2[61] and Fury®[62], but it's only a drone (UAS) who does the work, not realty a swarm of different unmanned systems, no USV/UGV/UUV.

- Marine and Land systems

Wide range of multi-mission marine craft and ground vehicles, logistical support

- Electronic systems

Simulation systems, test equipment, measurement systems

[59] https://www.textron.com/About/Our-Businesses/Textron-Systems

[60] https://www.textronsystems.com/missions/border-security

[61] https://www.textronsystems.com/what-we-do/unmanned-systems/tactical-family

[62] https://www.textronsystems.com/what-we-do/weapon-sensor-systems/fury

- Geospatial solutions

Advanced Analytics & Visualization (advanced geospatial analysis using imagery analysis, precision positioning and 3D visualization) and Enhanced Analytics.

7.10 *Magal Security Systems*

International provider of solutions, services and products for physical security, cyber security, and safety and site management.

Markets

Airports, Borders, Correctional facilities, Critical infrastructure, Energy, Safe city, Seaports, Smart city

Border solutions[63]:

- Early Warning: UAV, Radar, Long Range CCTV, Aerostat
- Fence Intrusion Protection: Mounted, virtual, buried sensors and detection means, PTZ cameras
- Border Checkpoints: face recognition, handheld scanning, vehicle examination, LPR, access control, barriers
- Surveillance and Interception: Local control centre, decision-making tools, machine learning and more
- Patrolling: mobile terminals and handheld enriched communication

Solutions:[64]

- Command and control

Ex. Fortis 4G: integrates video management, advanced debriefing capabilities and video tracking allowing operators and authorized personnel to make effective decisions based on real-time events, recognized threats or identification of suspicious individuals.

- Decorative indicative fence

Ex. Innofence: high quality fence with a concealed fiber optic sensor for intrusion detection.

- Military Grade Vibration Sensor

Ex. Fensor: advanced fence mounted perimeter intrusion detection system, sensor is easy to install on any existing fence structure.

- Perimeter Intrusion Grid

Ex. MagBar: intrusion detection solution that combines a massive physical grid with an embedded intrusion detection sensor, tailored to the specific dimensions of any pipe, drain, open tunnel, canal, air duct or window that it is meant to protect.

- Taut Wire Indicative Fence

Ex. YAEL: taut wire physical barrier combined with high performance sensors.

[63] https://magalsecurity.com/markets/borders

[64] https://magalsecurity.com/solutions

- Unmanned Surveillance

Ex. RoboGuard: agile unmanned robot which patrols around secured perimeters, capable of responding promptly to intrusion alerts.

7.11 *FLIR systems*

Large commercial company specializing in the design and production of thermal imaging cameras, components and imaging sensors.

For your life

Thermal imaging to enhance any lifestyle (recreational activities, night vision to detect wild animals, home repairs…)

For your work[65]

- Building Diagnostics Equipment, maintenance cameras, security systems, maritime systems, different types of cameras, traffic control systems.
- Different types of security systems
- Maritime systems: surveillance & targeting solutions, multi-spectral imaging for different mission

For your mission[66]

- Military & defence

Airborne: Star SAFIRE® series (sensors), the world's most widely deployed full-HD EO/IR[67] system
Land: Fixed and mobile surveillance systems, other imaging and radar solutions for land missions
Maritime: multi-sensor systems and targeting sensors for a range of missions (marine surveillance)

- CBRNE[68] Detection

Chemical sensors (ex. FLIR's Griffin instruments use spectrometry technology to detect, analyse, identify and confirm the presence of a wide range of other chemicals in air, liquid, and solid samples)

- Low enforcement

Wide range of thermal imaging products for military and law enforcement

- Maritime first responders

Sensors and imaging systems in support of search and rescue missions (airborne and maritime).

[65] http://www.flir.co.uk/work/

[66] http://www.flir.co.uk/mission/

[67] Electro-Optical/Infra-Red

[68] Chemical, Biological, Radiological, Nuclear, Explosives

7.12 *IAI - Israel Aerospace Industries*

World leader in the defence and commercial markets, delivering state-of-the-art technologies and systems in all domains: air, space, land, sea, cyber, homeland security and ISR

Most relevant business areas:

Remotely Piloted Aerial Systems

- Solutions[69] include a wide range of advanced remotely piloted aerial vehicles, carrying multiple electro-optical, radar and SIGINT payloads, and sophisticated ground control stations. Integrated Data Link Network for communications.

- RPAS for maritime solutions[70] (homeland security, paramilitary and wartime missions). Maritime RPAS system consists of at least three aircraft equipped with a ground and control station, a launch and retrieval station, a ground data terminal, a launch & retrieval data terminal and mission oriented payloads.

- Trainings: RPAS Academy (unique solution for training and certification of RPAS operators and technicians)

- Terrain Dominance[71], HERON RPAS is the most-advanced multi-mission, multi-sensor ISTAR solution for wide-area dominance, enabling accurate tracking of hundreds of diverse targets simultaneously. Optimal sensing spectrum, Radar, SIGINT and combined automated multi-INT processing in real time, operational in all-weather, day or night. New capabilities: remote operations

- PLUS[72]: comprehensive UAS commercial solution for Precision Agriculture, Oil & Gas and First Response.

Naval Systems

Comprehensive naval solutions ranging from integrated systems to security systems, unmanned aircraft and unmanned vessels for coastal and offshore platform security applications.

- Surveillance systems: different types of sensors (small and mid-range, day and night surveillance)
- UAS for maritime solutions (see RPAS section)

Intelligence, Surveillance, and Reconnaissance (ISR) System

ISR integrated solutions, AEW integrated solutions (Airborne Early Warning), SAR (Synthetic Aperture Radar), SIGINT systems (signals intelligence), Electro-optical payloads C4I (Command, Control, Communications, Computers and Intelligence)

3 relevant examples of solutions:

- ELI-3310 - Coastal Surveillance System[73]

[69] http://www.iai.co.il/2013/37153-en/Unmanned%20Air%20Systems.aspx

[70] http://www.iai.co.il/2013/35030-en/BusinessAreas_UnmannedAirSystems_MaritimeSolutions.aspx

[71] http://www.iai.co.il/2013/37150-47015-en/BusinessAreas_UnmannedAirSystems.aspx

[72] http://www.iai.co.il/2013/37404-48871-en/BusinessAreas_UnmannedAirSystems.aspx

[73] http://www.iai.co.il/2013/36665-38584-en/BusinessAreas_ISRSystems.aspx

Innovative, 24/7 all-weather solution for protection of homeland coastal shores, incorporating new technologies. Provides cost-effective solution for missions such as prevention of illegal activities, traffic control, prevention of terrorist activities, and support for Search and Rescue operations. The system includes fixed and/or mobile coastal stations, operated locally or remotely, and a Command and Control Centre, which informs low enforcement units in real-time so that action can be taken to intercept the target and eliminate the threat.

- ELI-3330 - MPAS - Multi-Payload Aerostat System[74]

Overcoming obstacles of Line-Of-Sight, MPAS provides a cost-effective solution for continuous surveillance and monitoring of long border-lines, coastlines or the peripheral surroundings of high value sites. The baseline MPAS consists of an aerostat carrying onboard a surveillance radar and an imaging sensor. In this configuration the system can scan, detect, identify and track vehicle and pedestrian movements within a wide region of interest and at ranges that exceed 20 Km.

- ELI-3350 - MSISS - Multi-Sensor Intelligence and Surveillance System[75]

Command & Control system designed to support a broad spectrum of operational scenarios. MSISS provides real-time situation awareness picture of the theatre and mission tasking recommendations. A wide variety of airborne, ground, surface and sub-surface sensors is processed by the system. Collected data is afterwards relayed to command hierarchy for operational decision making.

Land systems

- Attack systems
- Defence systems (missile defence systems and minefield breaching systems)
- C4ISR (ground based radar systems, surveillance systems, integrated solutions see ISR systems)
- Unmanned systems (robotic systems for different purposes, bird-eye family for “over-the-hill intel, VTOL family, Vertical take-off and landing RPAS)

Example of USV used for border defence: Guardium[76]
The Guardium USV is an autonomous fence & border protection system which can be mounted on a variety of field proven platforms. Guardium is based on a unique algorithmic expert system that functions as a ‘brain' to allow decision-making capabilities. Guardium has the ability to autonomously travel at up to 48 mp/h to intercept intruders on a fence & border perimeter before security personnel can arrive and increases protection without requiring a massive deployment of resources.

Homeland security (HLS)[77]

- Cyber solutions (End-to-end cyber security & monitoring tools addressing intelligence, protection, monitoring, identification and accessibility)
- Robotic systems (for different purposes, see Guardium example in previous paragraph)
- Border protection (different systems, for examples see ISR chapter)

[74] http://www.iai.co.il/2013/36665-34555-en/BusinessAreas_ISRSystems.aspx

[75] http://www.iai.co.il/2013/36665-34543-en/BusinessAreas_ISRSystems.aspx

[76] http://www.iai.co.il/2013/37135-31663-en/Business_Areas_Land.aspx

[77] http://www.iai.co.il/2013/16130-en/Business_Areas_HomelandDefence.aspx

- Tactical radars (Ground, coastal, & air radar systems)
- COMINT (Communication Intelligence system for airborne passive GSM interception & monitoring)
- Traffic management (ELK-7029 - Air/Vessel Traffic Control Direction Finder System)
- Electro-optical systems (Surveillance systems for homeland defence)
- Remotely piloted systems (wide range of RPV solutions including advanced remotely piloted aerial vehicles, carrying multiple electro-optical, radar and SIGINT payloads, and sophisticated ground control stations)

7.13 *Kelvin Hughes*

World leader in the development, manufacture and supply of maritime navigation, surveillance and security radar systems.

Security systems

- Border solutions[78]

Complete radar based solutions for border security and border surveillance applications. Systems can be a single SharpEye™ SxV mobile radar or part of a multi radar and electro optic camera system deployed via our innovative SMS (Single Mast Solution) for mobile and semi-permanent requirements, manned and unmanned containerized radar and surveillance suite solutions for long range border surveillance.

- UAV detection[79]

SharpEye™ SxV radar optimised for the detection of drones, quadcopters, UASs and UAVs. Complete radar-based solutions for border and perimeter security and SharpEye™ with its ability to detect small low aerial targets even in clutter conditions makes it the ideal sensor to detect and provide early warning of the operation of UAVs.

- Port & harbor security[80]

SharpEye™ SxV deployed on a Kelvin Hughes Single Mast Solution (SMS) combining electro optic slew to cue cameras or a SharpEye™ Long Range radar provides 360-degree surveillance of critical port or harbour perimeters, inlets, keys and docking areas.

- Mobile surveillance solutions[81]

Complete radar based mobile surveillance solutions for integration with vehicles whether they are a standard commercial vehicle or a military vehicle. Systems can be deployed as a single SharpEye™ SxV mobile radar integrated with a vehicle mounted telescopic mast system or a self-contained trailer. Either method utilises the innovative Single Mast Solution (SMS) which cleverly combines radar and electro optic camera sensors on a single platform.

- Other areas

[78] https://www.kelvinhughes.com/security/border

[79] https://www.kelvinhughes.com/security/uav-drone-detection

[80] https://www.kelvinhughes.com/security/port-and-harbour

[81] https://www.kelvinhughes.com/security/mobile

Battlefield surveillance, Wildlife & game park solutions, Airport solutions, Base protection and Perimeter & CNI (critical national infrastructure) protection.

Maritime systems

- Naval radar[82]

SharpEye™ naval radars are able to see small targets in sea, rain or land clutter that others will miss.

- Small boat radar[83]

SharpEye™ SCV is an advanced surveillance radar sensor that fills the capability gap between leisure boat marine radars and naval tactical radar systems. SharpEye™ technology is specifically designed to detect targets earlier and at longer ranges than conventional small boat radars, particularly in adverse weather conditions.

- Coastal surveillance radar

Protect coastlines by providing SharpEye™ fully coherent radars capable of detecting uncooperative low Radar Cross Section (RCS) targets such as small wooden boats and RHIBs that maybe operating illegally off the coast or in an EEZ area, trafficking or providing entry into the country through remote unprotected shorelines.

- Other areas:

Helicopter guidance, Submarine solutions, VTS (Vessel Traffic Service) radar, Offshore radar, Commercial ships navigation and Safety systems (environmental and safety applications)

7.14 *OptaSense (a QinetiQ company)*

Manufactures, installs, maintains, and operates distributed acoustic sensing systems

Perimeters[84]

The OptaSense Perimeter Intrusion Detection and Security system (PIDS) using advanced distributed acoustic sensing (DAS) technology capable of identifying and locating multiple threats in real time, with point-locating capabilities to 10m.

Applications: Buried, fence mounted or hybrid installations, borders and military, utilities, industrial, transportation, commercial, VIP residences / golf courses / resorts.

Borders & Military

OptaSense Border and Military Security solutions strengthen security efforts by delivering real-time, actionable intelligence. Using advanced Distributed Acoustic Sensing (DAS) technology, these solutions provide agents and field patrols a complete picture of the location, scale and type of threat detected—enabling rapid, more informed decisions that result in fast and efficient response mechanisms.

Applications:

[82] https://www.kelvinhughes.com/maritime/naval-radar

[83] https://www.kelvinhughes.com/maritime/small-boat-radar

[84] http://www.optasense.com/security/

- Border security & Surveillance[85]

OptaSense border security and surveillance system: multi-threat detection (advanced sensors capable of detecting changes in pressure, temperature, stress and acoustics and advanced algorithms which help the system classify and locate activities), system operations (all alerts are displayed in real time using a map display that allows operators to monitor very long distances), deployment options (standard burial, fence or wall mounted, horizontal directional drilling or borehole drilling)

- Military asset protection

Other areas:

Pipelines, Oil & Gas, Transportation, Power & Utilities

7.15 *Rockwell Collins*

Multinational company providing avionics and IT systems and services to governmental agencies and aircraft manufacturers

Commercial and Business Aviation

Innovations in flight deck, cabin, airport and communication technologies along with more powerful and flexible worldwide air and ground networks.

Defence & Government[86]

- Electronic Warfare

Deployed electronic intelligence (ELINT) and electronic support measures (ESM) solutions such as perimeter surveillance radar system.

- Defence & Government Service Solutions

Mainly military solutions, no border security

- Others

Avionics, Communications, Displays & Controls, Lighting, Navigation, Optronics, Oxygen & Passenger Service Unit Systems, Targeting, , Simulation & Training, , Government aviation connectivity, Platforms.

Critical infrastructure

ARINC UrgentLink Command and Control security Systems, Cybersecurity Solutions, Public Safety Systems.

7.16 *Rolls Royce Holdings*

Multinational company which designs, manufactures and distributes power systems for aviation and other industries. Rolls-Royce is the world's second-largest maker of aircraft engines and has major businesses in the marine propulsion and energy sectors.[87]

[85] http://www.optasense.com/borders-military/border-security-surveillance/

[86] https://www.rockwellcollins.com/Products-and-Services/Defence.aspx

[87] https://www.rolls-royce.com/products-and-services.aspx

Civil aerospace

Airlines, Business Aviation, Helicopters, Future products, Aftermarket Services

Defence aerospace

Combat Jets, Rotary, Transport Tanker Patrol & Tactical, Trainers, UAVs, Services, Advanced Technology

Rolls-Royce manufactures UAVs[88] for intelligence, reconnaissance, and surveillance missions such as the Global Hawk (produced by Northrop Grumman but empowered by Rolls-Royce engine), the Triton and the Embraer 145.

Power systems

Engines, propulsion and distributed energy systems

Marine

Broad product range (cranes, different machinery, engines, power systems, turbines, propulsors…)

Nuclear

Extensive nuclear certified supply chain expertise

7.17 *Saab Group*

Aerospace and defence company

Aeronautics

Advanced development of military and civil aviation technology. Long-term future studies of manned and unmanned aircraft as preparation for new systems and further development of existing products.

Dynamics

Product portfolio comprising ground combat weapons, missile systems, torpedoes, unmanned underwater vehicles and signature management systems for armed forces as well as niche products for the civil and defence market such as underwater vehicles for the offshore industry.

Surveillance

Solutions for safety and security, for surveillance and decision support, and for threat detection and protection. The portfolio covers airborne, ground-based and naval radar, electronic warfare, and combat systems and C4I solutions.

- Airborne surveillance[89]
Range of airborne solutions comprises the world's most advanced multi-role fighter (Gripen), the GlobalEye AEW&C solution and Saab 2000 Erieye AEW&C system and a range of fully autonomous and mobile unmanned systems (for maritime, civil and land surveillance)

- Sensor systems[90]

[88] https://www.rolls-royce.com/products-and-services/defence-aerospace/uavs/ae-3007.aspx#/

[89] https://saab.com/air/#airborne-solutions|21083

[90] https://saab.com/air/#sensor-systems

Systems for airborne early warning, airborne fire control, ground imaging, reconnaissance and ground based air defence. Highly interoperable, capable and available sensor systems designed to support capability growth.

Other business areas:

Support and Services, Products and Services, Kockums (naval systems)

7.18 *Safran*

Multinational aircraft engine, rocket engine, aerospace-component and defence company

Aviation[91]

Supplies engines and equipment to all main producers of civil and military airplanes and helicopters, wide range of aircraft systems and equipment, navigation and other avionics systems,

Space[92]

Understand and apply all enabling technologies for different types of rocket propulsion, major player in the satellite market (propulsion and equipment)

Defence[93]

- Optronics

Involves detection, image processing and stabilization functions. Various military applications: surface ships, submarines, combat vehicles, aircraft and UAVs, infantry soldiers.

- UAVs

Tactical drones able to perform a number of different missions: surveillance, intelligence, early warning, artillery and gunship guidance, protection, manoeuvre control, as well as threat detection.

- Border and sensitive site surveillance[94]

Wide range of optronic solutions for border protection and critical infrastructure and sensitive site defence. Detection and reconnaissance systems are flexible and can be installed on vehicles or permanent stations in roaming or network mode. High-performance imagers and optronic sensors (thermal camera, infrared detector, laser rangefinder etc.), an optimum observation range of up to 25 km day and night, wide-dynamic high resolution screens and a user-friendly man-machine interface, guaranteeing real operational effectiveness with maximum autonomy.

Example of solution: OWLSMART.i

Smart observation with low signature. OwlSmart.i is an innovative means of gathering information remotely and discretely in order to trace presence in areas of interest. In addition

[91] https://www.safran-group.com/aviation

[92] https://www.safran-group.com/space

[93] https://www.safran-group.com/defence

[94] https://www.safran-electronics-defence.com/security/border-and-sensitive-site-surveillance

to its self-powered capability and its encrypted communication, it offers modular and scalable configurations. The OwlSmart.i solution integrates a common mesh radio network with a set of self-powered ruggedized sensors and cameras and a tactical command and control computer (C2)

- Other areas:
Navigation systems, Missile propulsion, Guidance, Warfighter modernization programs, , Avionics

7.19 *Smiths group*

Multinational diversified engineering business. Smiths Group has five divisions, Smiths Detection is the world's largest manufacturer of sensors for the detection of explosives, weapons, chemical agents, biohazards, narcotics and contraband.

Aviation[95]

Checkpoints solutions, Hold baggage solutions, Air Cargo solutions, Proactive services

Ports and borders[96]

Sea port terminal, Land border crossing (heavy cargo and vehicles inspections, mobile screening solutions, explosive and narcotic trace detection, detailed-analysis software platforms), Smarter ports & borders (CORSYS, cloud-based and digital ecosystem enabling a customs administration to control its entire security operation from a single, secure, one-world window)

Defence[97]

Base & site security, narcotic and explosive detection, chemical and radiation detection, cargo and vehicle inspection

Urban security[98]

Building security, Event & attraction security, mass transportation, emergency response

7.20 *Concluding Remarks*

One of the main objectives of the competitors' analysis was to understand, whether a similar solution to ROBORDER was already on the market or not. If we take into consideration every component of ROBORDER system (the swarm of unmanned vehicles, the different radars and mobile sensors, all software modules, etc.), the analysis shows that many key players in the market have been selling their products in the market for years. But, in view of the above, an intelligent holistic solution with all ROBORDER functionalities does not z seem to exist yet.

[95] https://www.smithsdetection.com/market-sectors/aviation/

[96] https://www.smithsdetection.com/market-sectors/ports-borders/

[97] https://www.smithsdetection.com/market-sectors/defence/

[98] https://www.smithsdetection.com/market-sectors/urban-security/

The first finding is that a vast majority of the companies analysed are investing in unmanned vehicles especially for military (given the fact that many of those companies are defence contractors) but also for civil and commercial uses. A predominance of UASs can be observed in the companies' products portfolios, followed by UGVs (USV and UUV seem to be less used for now). This common trend of investing in unmanned systems shows that market is indeed growing, as already indicated in the market context chapter.

Competitors can be divided in 2 groups in terms of solutions specific to border security.

- A first one, which regroups around 70% of the total number, provides solutions for border security but either there is not a holistic system in place or there is a system but with limited functionalities compared to ROBORDER ones. This is the case for instance of FLIR systems, which is specialised in thermal imaging cameras and imaging sensors and does not offer a multifunctional system to end-users. Another example is Raytheon, which does provide UAS systems but with "limited" functionalities (that is the case of the Coyote UAS system which performs exclusively intelligence, surveillance and reconnaissance missions).
- A second smaller group of companies does offer a more holistic system for border security, but none of those solution provide exactly the same functionalities of ROBORDER. The list of those companies include Leonardo, Magal Security Systems and Israel Aerospace Industries (IAI) and a few others.

Many of the companies analysed are also involved in EU projects in the defence and security areas (Leonardo and Thales) as well as in the development of some SESAR solutions.

What ROBORDER has in common with all competitors are the surveillance functionalities of the system (even though the radars and sensors deployed can differ) and the command and control functionalities (capacity to provide situational awareness and to respond to threats). On the other hand, the 2 main points of difference between ROBORDER and the other systems are:

- ROBORDER does make use of a swarm of unmanned vehicles while some systems only rely on static surveillance or mobile but based on manned vehicles
- ROBORDER can respond to varying operational, environmental and geographical conditions while other competitors' systems are limited in that sense. For instance, they only focus on sea borders or they only focus on detection of unauthorised access and don't allow the detection of pollution accidents.

One of the reasons why it is not easy to find a similar solution to ROBORDER in the market is that great majority of the competitors are key actors in the military sector, and therefore adapt their solutions to military needs and requirements, which is not exactly in ROBORDER's scope.

From an objective competitors analysis like the one conducted one can also find that some companies have developed systems or provide solutions that ROBORDER does not provide; this is not to be considered a weakness but more of potential additional functionalities to be implemented in the future. Some companies for example have implemented facial recognition (biometrics) solutions at the borders, others have built "smart fences", more offer radars capable of detecting chemical, biological, radiological, nuclear and explosive elements. The same goes for extra border applications of the solutions: many companies for instance offer systems capable of securing ports and other critical infrastructures.

8 Key Activities and Requirements for ROBORDER

This section presents various aspects of user needs. ROBORDER concept is based on the interaction and discussion with end users because it allows to optimize the business process and ultimately deliver a system which really facilitates their work. Input from end-users is a key element for the success of any project, this is also one of the reasons why several members of ROBORDER consortium are end-users; their participation testifies the existence of a market and constitutes a good basis for potential customers.

This section provides the first input on the understanding of the customers, which requirements are presented in the figure 16 below. In addition, this section also presents their needs, which modelled requirements are presented in the Value proposition section.

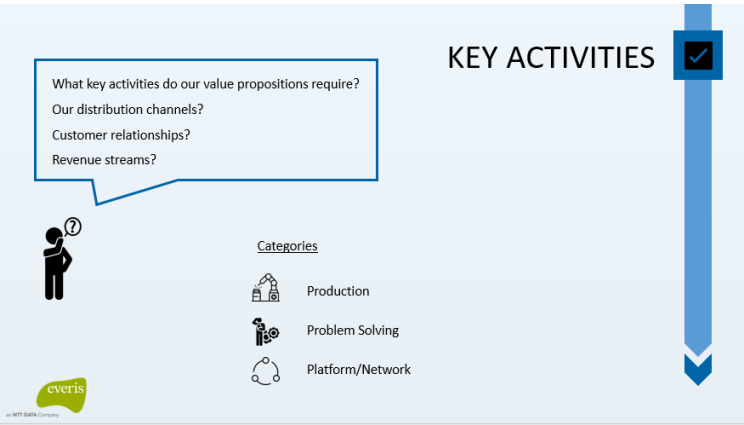

Figure 20 – Key Activities aspects to be covered within Exploitation Plan

8.1 *Technical requirements*

This section describes all the functional requirements that were collected from all the technical partners. All the technical components required by work package or that are necessary to manage correctly the system are described.

The following figure provides an overview of those requirements, which have been mapped with the XMind tool. Seven areas have been identified: Information Technology (IT), Security (SEC), Command and Control (CC), Communication (COM), Sensors (S), Unmanned Vehicles (UV) and Data Fusion (DF).

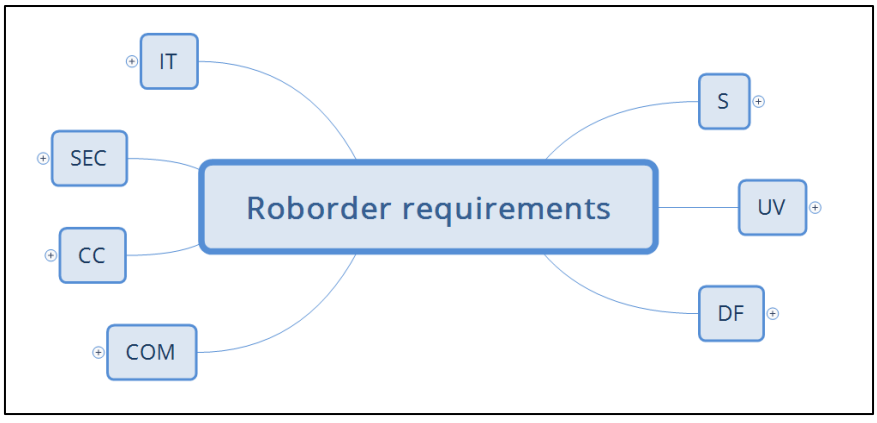

Figure 21 – Overview of the 7 areas of the technical requirements

Sensors

S-0001	The unmanned platforms have to be equipped with all type of sensors needed for detection
S-0002	ROBORDER platform should implement state-of-the art passive radar sensors
S-0003	The unmanned platforms sensors will identify the type of the objects that are present in the ROBORDER guarded area/s and their payload
S-0004	The unmanned platforms have to be equipped with all type of sensors needed for tracing
S-0006	The UAV have to be able to track (using its sensors) at least two different targets in the same time, located in an area of two square kilometres
S-0007	For water and underwater unmanned platforms all sensors have to be waterproof
S-0008	For the aerial and ground unmanned platforms all sensor should be waterproof
S-0009	The ROBORDER system will collect the weather data from mobile weather sensors spread in zones of interest
S-0010	ROBORDER platform should detect and recognise threats on different real operational environments (e.g. cliffs, high vegetation,)
S-0011	ROBORDER platform should detect UAV
S-0012	ROBORDER platform should implement state-of-the art passive radio sensors
S-0013	ROBORDER system should be able to detect small vessels.
S-0014	ROBORDER system will be able to detect underwater targets
S-0015	ROBORDER platform should be able to detect ground vehicles.
S-0016	ROBORDER platform should be able to detect the pollution areas.
S-0017	ROBORDER system will have a low rate of false detection

Unmanned Vehicles

UV-0001	The unmanned platforms have to operate on air
UV-0002	The unmanned platforms have to operate on ground (UGV)
UV-0003	The unmanned platforms have to operate on water
UV-0004	The unmanned platforms have to operate underwater
UV-0005	The unmanned platforms have to be waterproof
UV-0006	ROBORDER system will be able to be deployed in real operational environment.
UV-0007	The ROBORDER system have to be easily moved and deployed in the needed areas
UV-0008	The unmanned vehicles will be low energy consumption, by design, using as much as possible solar energy panels.
UV-0009	The unmanned vehicles will have unmodified performances in electromagnetic interference environments.

Data fusion

DF-0001	Data fusion will be performed only on the ROBORDER data fusion module
DF-0002	Data fusion will provide the information regarding tracking the position of targets
DF-0003	The data fusion will process the data sent by all type of sensors whether they are received from the ROBORDER system sensors or from fixed sensors provided by end users
DF-0004	The data fusion will provide a set of required data that could be analysed
DF-0005	The data fusion module will use the data received from the fix sensors installed in its range, provided by users
DF-0006	The ROBORDER data fusion module will be able to convert the raw data received from all types of sensors in needed data format for 3D digital maps production
DF-0007	ROBORDER system should recognise UAV
DF-0008	ROBORDER system should be able to recognize small vessels.
DF-0009	ROBORDER system will be able to recognize underwater targets
DF-0010	ROBORDER platform should be able to recognize ground vehicles.
DF-0011	ROBORDER system will have a low rate of false recognition

Communication

COM-0001	The system must assure all needed communications. Between all its modules.
COM-0002	ROBORDER platform must assure all interfaces needed for interconnection to other surveillance infrastructures, command and control rooms, databases and so on.
COM-0003	All ROBORDER system communications will be performed as main or backup through 4G networks
COM-0004	ROBORDER system will be interconnected to LEAs' Command and Control Room (CCR)

Command and Control

CC-0001	The command and control module will allow the operator to have access at all data captured by sensors
CC-0002	The command and control module will have its own maps database
CC-0003	The command and control module will allow many than one operator to operate the ROBORDER system in the same time. One operator will be, always, main and able to distribute task to the other operators
CC-0004	All information processed by ROBORDER platform will be displayed on CCR.

Security

SEC-0001	All communications used by the ROBORDER system have to be secured (coded)
SEC-0002	The unmanned technologies used in to ROBORDER system have to be foreseen with safety measures (procedural, mechanical, software) in order to avoid the harm of any live being (human, animal, plants) or environment.
SEC-0003	The producers/vendors of shelf technologies used in ROBORDER system will provide a safety measures brochure explaining all aspects that have to be follow in order to avoid any kind of

	accidents, both caused to the operator, live being and environment.
SEC-0004	The ROBORDER IT platform (software) will be deployed on application/internet servers on the end user premises
SEC-0005	Health and safety procedures conforming to the local / national guidelines / legislation should be followed.
SEC-0006	Ethics approval is required for all tests involving humans.

Information Technology

IT-0001	The IT platform (ROBORDER system software platform) will be composed, at least from following interconnected software modules
IT-0002	The IT platform will own a risk analysis module
IT-0003	The IT platform will own a face recognition module
IT-0004	The IT platform will offer software interfaces in order to be able to receive alerts
IT-0005	ROBORDER IT platform should be able to detect, recognise and display multiple threat agents simultaneous.
IT-0006	ROBORDER platform should be able to recognize the plate identification numbers of the ground vehicles.
IT-0007	ROBORDER IT platform will perform an automatic operational field assessment evaluation.
IT-0008	ROBORDER platform will be able to detect cyber and cyber-physical attacks.
IT-0009	SIMROB application will coverage all use cases

Requirements can be classified as functional and non-functional. While functional requirements capture the behaviour of a system, non-functional requirements (NFR) are a set of qualities that are valuable to stakeholders and constraints that affect planning, design and architecture decisions in different ways

8.2 *Functional requirements*

- Sensing, robotics and communication technologies (WP2)

  - Passive radar - FHR
  - RF signal sensor on board UxVs - ELTM
  - Re-configuration of agents and carrier solution
  - MONICA
  - Photonics-based radar network – CNIT

- Detection and identification of border-related threats (WP3)

  - Detection of pollution incidents
  - Identification and tracking of illegal activities
  - Low level fusion of sensor data
  - Intrusion Detection and Classification Module
  - Identification of unauthorized communications using RF sensor

- Command and control unit functionalities (WP4)

- Mixed reality robot control UI
- DSL-based mission specification (MDL editor)
- Autonomous resource task coordination
- Representation model and semantic reasoning
- Risk model Component
- Visual analytics and decision support

- Integration of ROBORDER platform for the remote assessment of border threats (WP5)
  - Mission dashboard
  - C&C configuration application
  - Mission execution
  - Mission control
  - Devices management

8.3 *Non-functional requirements*

- **Open standards:** data will be serialised and exchanged using open, well-known formats and standards (e.g. JSON, RDF) Open standards are easy to parse, easy to debug, are well understood and have lots of tools that support them.
- **Interoperable**: functionality will be exposed as an API of services accessed by HTTP; the underlying technology of each service implementation will be hidden in such a way that it could be changed in the future without any impact on the rest of the system. Services will not expose implementation details and operate on simple, platform-independent data transport objects.
- **Service oriented**: the platform will be built as an orchestration of discrete pieces of functionality, exposed as services to the rest of the system. Services will communicate with each other via the HTTP protocol, using the REST architectural design pattern and the docker configuration system.
- **Scalable**: the platform needs to be designed in such a way that it can be scaled to deal with increasing amounts of data and assets. No single element can compromise the ability of the platform as a whole to grow.
- **Reusable**: where possible, discrete pieces of functionality of the platform should be reusable, i.e., they should have the least possible amount of dependencies on other elements and be able to operate with little or no shared context. Services will be designed to be self-descriptive and self-contained, where possible.
- **Location-independent:** the platform will run on a logically and geographically distributed infrastructure; there will be a mix of processes running in partners' premises and processes running in cloud infrastructure. The platform will allow for transparent orchestration of these resources and relocation of individual elements as required.
- **Iterative:** the architecture will allow for iterative or evolutionary development. Starting from a backbone of placeholder and dummy services which will be put in place early in the project, additional capabilities and increasing functionality will be added without major changes to the overall design of the platform. Having a working end-to-end solution very early helps detect problems early, provides everyone with a complete vision from the beginning, and helps evaluate progress by providing tangible, measurable improvements over time.

- **Simple:** as a general design principle, the platform as a whole should be easy to understand, both in terms of processes and topology. Service and pipeline design will be built on the “principle of least surprise”: interactions, dependencies and side effects will be kept obvious.

9 User Persona, Characteristics and Potential Customers

This chapter is concentrating on a very particular aspect of ROBORDER project – the distinction between ROBORDER users and ROBORDER customers. Customer in market analysis usually correspond to the buyer, who is in principal responsible for the financial or other transaction to acquire a product or the service. However, as the analysis revealed the end user and the buyer are not corresponding to the same entity in the case of ROBORDER system acquisition, and there are specific rules defining the acquisition of such systems as ROBORDER within the EU.

Thus, this chapter is structured as follows. The first section presents the possible end users, what are their needs and what we practically learned from end-users and other relevant stakeholders during the qualitative study via questionnaire. This section specifically contributed to the ROBORDER development and value proposition, and key activities identification, which has been presented in the Chapter 8.

9.1 *End Users, Their Characteristics and Needs*

End users are the persons/organisations who will ultimately use or is intended to ultimately use the ROBORDER system, as already anticipated in the methodology chapter we identified five types of end-users organizations:

- National authorities responsible for border control (Border Police, National Guard or other border forces)[99]
- EU agencies involved in border control and fight against human trafficking (FRONTEX, EUROPOL)
- National authorities and agencies involved in integrated border management
- Military units
- International organisations and agencies

It is necessary to specify that international organisations and agencies, such as Frontex (European border and coast guard agency) or Europol (EU Agency for Law Enforcement Cooperation), can be considered end-users (if they buy and use the system themselves) or simple buyers (if they make nationals LEAs use the system after purchase).

Before going into the details of the functional and non-functional requirements an high level overview of user needs is provided together with the end-users’ survey results.

9.2 *EU Defence Procurement Rules*

Defence procurement is the process through which authorities in the field of defence acquire the various goods, services or works they need in order to perform their duties and missions.

[99] Listed in Annex 1 of the Practical Handbook for Border Guards (Schengen Handbook)

As a result of this combination of strategic and security imperatives and the complexity of the subject matter, many countries around the world have introduced differentiated procurement legislation in the field of defence that departs from the general standards of openness and transparency that are usually required in public procurement.

The European defence market is highly fragmented, procurement is run on a national basis and this often leads to unnecessary duplication of capabilities, organisations and expenditures. These differences across national lines discouraged and in some cases even prevented cross-border competition. As a result, there has so far never been a genuine pan-European defence procurement market but rather multiple national markets fenced off with regulatory barriers to entry aimed at protecting national defence industries.

9.3 *The EU Directive on Defence and Sensitive Security Procurement*

The EU Directive 2009/81/EC[100] on defence and sensitive security procurement sets out European rules for the procurement of arms, munitions and war material (plus related works and services) for defence purposes. It also sets out rules for the procurement of sensitive supplies, works and services for security purposes. These rules are adapted to the specificities of defence procurements, which tend to be particularly complex and sensitive. The Directive provides rules that enhance transparency and openness in defence markets between EU countries, while also ensuring that individual countries' security interests are protected.

Directive 2009/81/EC contains a number of innovations tailored to the specific needs of procurement in defence and security markets. These include:

- Awarding authorities may use the negotiated procedure with prior publication as a standard procedure, which gives them flexibility to fine-tune all details of the contract;
- Candidates may be required to submit specific guarantees ensuring security of information (safeguarding of classified information) and security of supply (timely and reliable contract execution, especially in crisis situations).
- Specific rules on research and development contracts strike a balance between the need to support innovation and the necessary openness of production markets.
- Awarding authorities may oblige contractors to award subcontracts in a competitive manner, opening-up supply chains and creating business opportunities for small and medium-sized enterprises (SMEs) in the defense and security sector;
- A set of national review procedures will provide effective remedies to protect the rights of businesses taking part in the award procedure.

A European Commission evaluation report on the Defence Procurement Directive 2009/81/EC[101] concluded that it helped open up the internal market for defence but that much more progress is needed. A significant share of expenditure, especially for high-value, strategic, complex defence systems, is still done outside the Directive and the degree of application remains uneven across EU countries. To address this situation, the report underlines the strong need to focus on the effective implementation of the Directive and

[100] of 13 July 2009

[101] Published on November 2016

proposes a number of actions such as guidance on the interpretation of specific provisions, dialogue with EU countries, enforcement actions, and scoreboards on countries' use of the Directive.

9.4 *Potential Customers*

As already established in the methodology section, end-users and potential customers are two separate things in the market. The formers (national police and border authorities) neither choose nor buy, but just use the system, platforms and vehicles; the latters (internal affairs, security agencies) are the buyers and, in a way, the real responsible for border security.

In this regard, the potential customers for ROBORDER are any authorities, which have the right to award the contracts, and might not necessarily be in relation to border security and surveillance. It appeared that it very much depends on each country within the EU, and how the centralised or decentralised the government authorities are. It also became evident that there is huge disparity between end users and contracting authorities, and the process between the order of the certain equipment for border control to actual use of the technology can be as long as 5 years (Hungarian case).

Operating in this market means that technological trends have to be taken into account very well. The actual and possible situation of 5 years period between the request for technology and its acquisition has to be properly translated into the pricing mechanism and the ROBORDER technological development too. Strategic planning for the upcoming technologies have to be put in place, and the attention to technology maturity level should be taken into consideration for the costs of ROBORDER development in the future. Additionally, this data is extremely relevant for the business plan and long-term exploitation plan, as the long terms between technology creation, its marketing, the issued requests of end-users and the procurement procedure by awarding authorities play a huge role in ROBORDER's long-term sustainability and operating costs before obtaining revenues, and even more the profit from the selling the system.

10 Relevant Legislation for ROBORDER Operation

Regulation is of critical importance for the successful implementation of the ROBORDER concept. The objective of a regulatory policy is to ensure that regulation works effectively, and is in the interest of all the stakeholders, including the public. Regulatory policy related to border management and to the use of unmanned vehicles is taking shape in different ways across the EU member states, but the current situation is rather fragmented and there is no established regulatory framework in Europe, extremely important especially when it comes to the application of robots for low enforcement purposes.

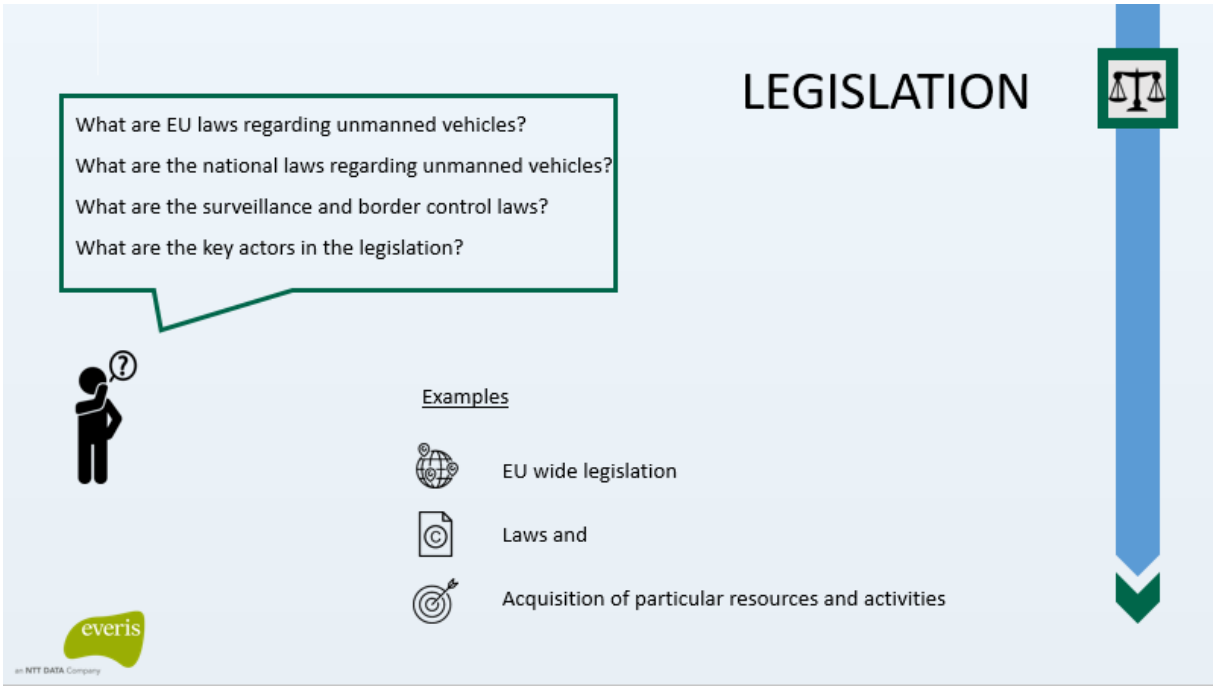

Figure 22 – Overview of the Legislation aspect in the created framework for ROBORDER

In this section a short analysis of the regulations will be provided; the section will begin with a basic introduction to borders to enable better understanding between end-users and technical partners, than proceed with a quick overview of the existing UAVs related regulations at international, EU and national level and finally end with a chapter examining of the regulations associated with the specific products (UAV, UGV and USV/UUV) and the sector of activity and another chapter about data and GDPR.

10.1 *Introduction to borders*

10.1.1 History and types of border

Borders have existed since the early times of human civilization and their purpose has changed overtime: from “keeping anything else out” until the Roman Empire to interface for trade and place of taxation later on. Also the territory border define changed over time: empires and big territories in the past, cities and tenures in the middle age and countries nowadays. But in reality, borders always had two ambivalent purposes: to separate and connect. Separate an area controlled by a given group of life forms from areas controlled by other groups or by no one and connect or keep members of the group together by serving as identity basis for the socio-geographical group.

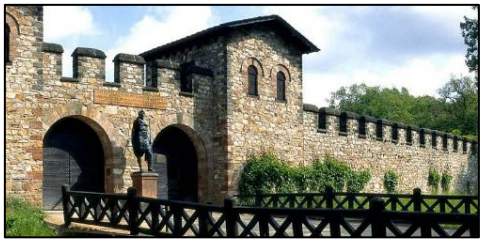

Figure 23 - Upper Germanic-Rhaetian Limes

If borders are not able to fulfil any of their two purposes, the existence of the nation-state itself becomes endangered. The same danger arise, when they are shifted radically to one of the two purposes. Delimited by international treaties and demarcated by border sings, there are three types of borders:

open borders, which can be crossed at any time

controlled borders, where you can cross at border gates but otherwise it is prohibited

closed borders, which are more like frontiers

Figure 24 - Border between Germany and Austria

Figure 25 - Border between Hungary and Romania

Figure 26 - Border between North and South Korea

Figure 27 – The three types of borders

By type border can also be categorized according to their geographical features:

- Air borders
- Sea borders
- Land borders (including rivers and lakes)

Different other categorization also exists, like cultural, linguistic etc. but there are not relevant from the aspect of this project which is more focused on the geographical nature of borders. As mentioned before, most borders of the present are delimitated by international agreements. Delimitation means describing the principles where the borderline shall run and it's followed by the procedure of demarcations, the precise pinning of borderline by making different types of border signs. There are stale (or solid) borders, which are not changed after demarcated unless in a different international agreement and moving borders, which are changing as the environment changes around them.

Figure 29 – Border between Poland and Ukraine

Figure 28 - River Drava, natural border between Hungary and Croatia

10.1.2 Border regime

Border regime is the category of rules set in international agreements between two neighbouring states along their shared border, facilitating peaceful border relations, laying down procedures for settlement of disputes, common investigation of border cases and resolution of border incidents.

Border incidents are not always defined, some agreements include particular lists, and other ones only contain a vague definition. To present a more tangible example of how a border regime works and what are the typical rules, the following example has been taken from the Bucharest Treaty on Hungarian Romanian Border Regime[102]:

Border incidents are:

- Explosions with cross-border impact
- Cross-border weapon firing
- Armed trespassing
- Coercion of border crossing
- Deliberate violation of airspace
- Cross-border pollution
- Causing fire across the border or spreading cross-border
- Destruction of border signs

As privileged cases, is not considered as a border incident, but as a border case if:

- Trespassing was committed because of disorientation
- Roving animals crossing the border
- Air or water vehicles drifting into the neighbouring airspace or waters because of unavoidable circumstances or accidental event

In any case, it is not considered a border incident if the act is committed:

- With consent of the neighbouring state;
- Righteous defence;
- Vis major or other unforeseeable natural cause;
- In a justifiable case of emergency;
- As victim of coercion.

[102] Signed on the 20th of October 2005 in Bucharest.

Persons, animals or objects got into the territory of the neighbouring state during a border case or a border incident are handed back to the originating state in the shortest time at designated border gates by border representatives or their delegates.

10.1.3 Roborder operations compliance with border regime

During operation of the ROBORDER platform, UxVs has to operate in accordance with the border regime and may be involved in border incidents and border cases. Most of this involvement shall be as normal operation, like the UxV detecting the border incident or border case, identifying, tracking and recording it or support the border patrols to resolve the situation. Details of such role of ROBORDER platform is to be elaborated in WP3 and considered as basic feature of the system.

In the current section, the prevention causing a border incident or a border case with the platform is investigated and recommendations for resolutions are made. After an initial assessment, several border incidents and cases are selected as realistic to happen with UxVs and summarized in the following matrix table.

Event	Risk	Impact	Prevent	Resolve
Deliberate violation of foreign airspace	Medium	Medium	Acquire advance consent (MoU)	Return to home airspace as soon as possible, justify with vis major, natural cause or emergency
Cross border pollution (caused by crashed UxV)	Low	High	Apply ISO 14000 family on environmental management for the platform	Immediate notification of neighbouring state, assistance to clean pollution, compensate for damages, recover hazardous materials, investigate
Fire (caused by UxV)	Low	High	Apply 2006/42/EC on EU product safety framework for advanced robots & autonomous systems	Immediate notification of neighbouring state, assistance to extinguish, compensate for damages, investigate
Destruction of border signs by accident	Low	High	Equip border signs with transponders to help navigation	Notification of neighbouring state in case of two-sided or triplex border sign. Repair damage
UxV drifted into foreign airspace or waters	High	Low	Apply multi-layered navigation systems	Formal excuse, investigation and measures to prevent further cases

Table 3 – Summary of most common border accidents and cases

Sovereignty of countries and their airspace (including its territorial waters) is an essential element when planning a border control activity with state use any of the different types of unmanned vehicles. To avoid incidents between countries, in addition to current border regime, a certain contract, or other method to formalize an arrangement should be necessary.

If the contract is between ICAO[103] contracting states, the process could be smooth and be solved with a memorandum of understanding. However, technical faults can happen for different reasons also in non-EU states, if that is the case a cooperative approach is preferred. Bilateral or multilateral contracts could protect the operation in many ways and facilitate of the recovery of the UAV.

Memorandum of Understanding (MOU)	Letter of Acceptance (LoA)
A frame, usually signed by 2 or more parties, at ministerial level. Can reveal itself unhelpful without a LoA, as it simply means a gentlemen's agreement without enforceable measures	A coordinate agreement with detailed measures, rights, commitments and responsibilities. LoA gives an 'insurance' when an accident or incident occurs during border control UAV activity

Table 4 – Description of the 2 most commonly used agreements: Memorandum of Understanding and Letter of Acceptance

10.1.4 Border surveillance

Border surveillance means the surveillance of borders between border crossing points and the surveillance of border crossing points outside the fixed opening hours, in order to prevent persons from circumnavigating border checks. It is important not to mistake border surveillance with border checks, as the latter are carried out only at border crossing points, which is also the reason why they are irrelevant for the ROBORDER project.

More specifically, border surveillance:

Shall prevent and discourage persons from circumventing the checks at border crossing points
Shall be carried out by border guards whose numbers and methods shall be adapted to existing or foreseen risks and threats
Shall involve frequent and sudden changes to surveillance periods, so that unauthorized border crossings are always at risk of being detected
May also be carried out by technical means, including electronic means (fence, radars, cameras, patrol vehicles, helicopters, UxVs, boats…

Table 5 – Border surveillance main requirements

[103] International Civil Aviation Organization (ICAO)

10.2 *EU Regulations*

Individual states have developed their own UAV capabilities and policies in response to their perception of current and future security challenges. This individual development reflects both the changing global security context, and the regional security challenges facing the EU and its member states (the primary challenges include potential conflicts, migration and terrorism).

Many of the challenges facing the EU point towards greater convergence of approach, a greater deal of cooperation between EU states. There is a need for the EU to develop some form of common policy on UAVs in order to unlock the potential of this technology; the safe integration of unmanned aviation in the airspace is likely to require a new UAV management system and approach, and that should be the focus on EU policymakers.[104]

The key actors in the legislative process (described in chapter 10 - key partners) are the European Commission, the European Aviation Safety agency (EASA) and Eurocontrol.

10.2.1 European Commission actions

The Commission, being the body responsible for proposing legislation and implementing decisions for the EU, is probably the most important actor in all matters concerning UAV legislation. Here follow the most important actions taken by the Commission:

Regulation (EC) No 216/2008 of the European Parliament and of the Council (20 February 2008)[105]

Also called the "basic regulation" by the UAV community, its main aim is to set out the main rules and principles to establish and maintain a high uniform level of civil aviation safety in Europe, including the creation of a European Aviation Safety Agency (EASA).

This EU law applies to the design, production, maintenance and operation of aeronautical product parts and equipment, as well as to personnel and organisations involved in these activities.

The law also sets out the main tasks of EASA as well as the main rules of the agency including legal status, the powers and composition of the Management Board, and the powers and functions of the Executive Director.

In addition to EASA, the law sets out common rules for aviation safety including airworthiness, environmental protection, flight crew certification, aerodromes and air traffic control.

Communication "A new era for aviation: Opening the aviation market to the civil use of RPAS in a safe and sustainable manner" (April 2014)[106]

[104] Source https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2018-02-05-drones-eu-mcdonald.pdf

[105] Official summary of legislation http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l24492&from=EN&isLegissum=true , full text http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008R0216

[106] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014DC0207

The European Commission strategy was presented in this communication; however, the strategy focuses on Remotely Piloted Aircrafts Systems (RPAS), which therefore excludes fully autonomous systems.

It aims to ensure:

- Safe and secure integration of RPAS into the European aviation system
- A common safety regulatory framework
- The necessary enabling technologies
- Measures to ensure the protection of citizens
- Measures to support market development and European industries

This strategy has been endorsed by the aviation community in the Riga Declaration and was made public in March 2015 during the Latvian Presidency of the Council of the EU.

Adoption of proposal for the revision of EASA Basic Regulation 216/2008 (8 December 2015)[107]

Covers the necessary elements to enable the development of European safety rules for UAVs, this includes a transfer of competences to enable the EU to regulate UAVs of all sizes, including UAVs below 150 kg, which today are regulated at national level.

Warsaw declaration "Drones as a leverage for jobs and new business opportunities" (24 November 2016)[108]

Provides the principles for developing a UAV services market, the principles highlight the need to develop European safety regulations and the concept of the 'U-Space'.

Blueprint U-space concept (June 2017)[109]

The U-space blueprint sets out the vision for the U-space, which aims to enable complex UAV operations with a high degree of automation to happen in all types of operational environments, particularly in an urban context. When fully deployed, a wide range of UAV missions that are currently being restricted will be possible thanks to a sustainable and robust European ecosystem that is globally interoperable.

The blueprint has been drafted by the SESAR Joint Undertaking, the mechanism which coordinates and concentrates all EU research and development (R&D) activities in ATM, pooling together a wealth experts to develop the new generation of ATM.

The paper outlines 3 basic principles, which describe how the U-Space should be:

[107] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015PC0613

[108] https://ec.europa.eu/transport/sites/transport/files/drones-warsaw-declaration.pdf

[109] https://www.sesarju.eu/u-space-blueprint downloadable in PDF format (bottom of the page)

	Safe, the concept is to develop a system similar to that of Air Traffic Management for manned aviation
	Automated, the system will provide information for highly automated or autonomous drones to fly safely and avoid obstacles or collisions
	Up and running by 2019, for the basic services like registration, e-identification and geo-fencing, further services and their corresponding standards will need to be developed in the future

Table 6 – The 3 basic principles of the U-space concept

10.2.2 EASA actions

According to article 52 of the Basic Regulation EASA, through the rulemaking process, is bound to contribute to the production of EU legislation and implementation material related to civil aviation safety and environmental compatibility. As of 2018, the Rulemaking Programme is included in the European plan for Aviation Safety (EPAS).

EASA identified that UAVs are increasingly being used in the EU but under a fragmented regulatory framework: although national safety rules apply, the rules differ across the EU and a number of key safeguards are not addressed in a coherent way. That was the main reason why the agency created a draft of the new regulation for UAS operations in 'open' and 'specific' categories, called NPA (Notice of Proposed Amendment 2017-05[110]).

Opinion 01/2018 -"Introduction of a regulatory framework for the operation of unmanned aircraft systems in the 'open' and 'specific' categories"[111]

Following the consultation period of the NPA, EASA then published the Opinion 01/2018. Here follows a summary of the key points of the proposed framework:

- Implement an operation-centric, proportionate, risk- and performance-based regulatory framework for all UAS operations conducted in the 'open' and 'specific' categories
- Ensure a high and uniform level of safety for UAS operations
- Foster the development of the UAS market
- Contribute to addressing citizens' concerns regarding security, privacy, data protection, and environmental protection
- Provide flexibility to MSs by allowing them to create zones within their territories where the use of UAS would be prohibited, limited or facilitated

The proposed regulatory framework is expected to increase the level of safety of UAS operations, to harmonise legislation among the EU MSs, and to create an EU market that will reduce the cost of UAS and allow cross-border operations

The EU Commission is now discussing the Regulation proposed by EASA, the adoption is expected by the end of 2018.

[110] https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2017-05

[111] https://www.easa.europa.eu/sites/default/files/dfu/Opinion%20No%2001-2018.pdf

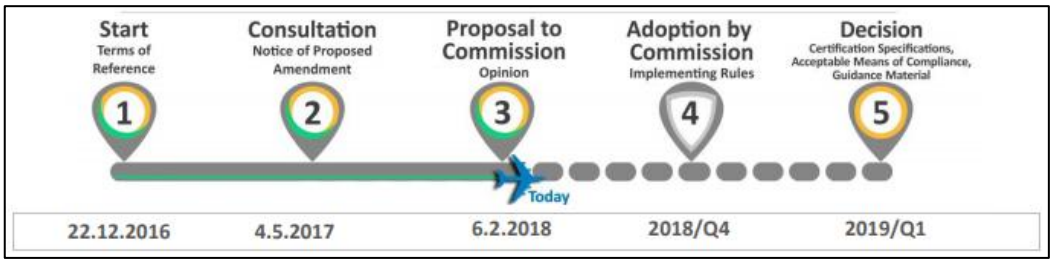

Figure 30 – EASA rulemaking process milestones

10.2.3 Eurocontrol actions

Eurocontrol is one of the main contributors of the European Piloted Aircraft Systems (RPAS) roadmap, it takes part of JARUS and it is also involved in the ICAO RPAS Panel. The organisation is currently leading and managing special studies and develop standards and recommendations to facilitate the safe, secure and efficient integrations of RPAS into non-segregated airspace and aerodromes. Furthermore, the agency:

- Provides support to the EU by giving a support to develop the EC roadmaps
- Plays an important role in the integration of RPAS by providing direct support to civil and military authorities that are in the process of integrating RPAS or developing regulations, ATM procedures or generic safety cases.
- Is working on operation in very low-level airspace

10.2.4 Next steps

The EU is constantly working at the development of the current status of the regulations on UAVs and on their operations. One way to stimulate the development is to gather informed opinions and suggestions from the public (citizens and organisations), for example via online public consultations.

There is currently an open consultation on unmanned aircrafts[112] with the objective of identifying what are the gains that could be brought by the use of UAVs and what are the concerns that would need to be addressed by EU public intervention.

The results of the consultation will feed into the forthcoming delegated and implementing rules on UAVs and their operations and possible future follow-up rules related to UAVs operations.

10.3 *International Regulations*

In the international realm, there is one main actor in the development of aviation laws, which is the ICAO (United Nations agency). The EASA and the other European bodies involved in the fields they all maintain close relations with ICAO on a wide range of activities. Another relevant actor in the regulation field at international level is JARUS, which is specialised in UAS/RPAS operations.

[112] Public consultation on drones (unmanned aircraft) – technical standards for drones as a product and conditions for drone operations. Open from 13 April 2018 to 9 July 2018, link to access: https://ec.europa.eu/info/consultations/2018-drones_en#objective

10.3.1 ICAO actions

ICAO declares that all unmanned aircraft, whether remotely piloted, fully autonomous or combinations thereof, are subject to the provisions of Article 8 of the Convention on International Civil Aviation.

> *Article 8 - Pilotless aircraft*
> *No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft*

Several articles of the Chicago Convention has direct connection with the UAS operations:

2011 - Circular 328-AN/190

Address all Unmanned Aircraft Systems and provides the aviation community with a definition of UAS, a description of the operational environment and a top-level functional breakdown.

Year 2014 – ICAO Doc 10019-AN/507 - Manual on Remotely Piloted Aircraft Systems (RPAS)

The purpose of ICAO in addressing RPAS is to provide an international regulatory framework trough Standards and Recommended Practices (SARPs) and guidance material. The scope of ICAO provisions is to facilitate integration of RPAS operating in accordance with:

-Instrument flight rules (IFR)
-In controlled airspace and
-At controlled aerodromes

The type of operations the ICAO panel focuses on is far from the basic concept of ROBORDER, but the strict standards and procedures in the manual give a favourable back up ground to further legal framework development. The basic purpose of UAV operations for border protection is not for international flight reasons.

ICAO has also developed an online UAS toolkit to assist States in developing national regulations for domestic UAS/RPAS operations.

10.3.2 JARUS actions

The JARUS guidance material aims to facilitate each authority to write their own requirements and to avoid duplicate efforts. JARUS does not develop industry standards and will not draft ICAO SARPs or guidance material unless ICAO requests so.

JARUS 7 Working Groups (WG) are focused on different aspects of UAS/RPAS operations:

- WG 1 – Flight Crew Licensing
- WG 2 – Operations
- WG 3 – Airworthiness
- WG 4 – Detect and Avoid
- WG 5 – Command and Control
- WG 6 – Safety and Risk Management

- WG 7 – Concepts of Operations

JARUS also works on a comparison chart of national regulations on UAVs, and has published on its website[113] a spreadsheet displaying the current RPAS regulations/rules implemented in some of the countries all around the world.

10.4 *National legislation*

10.4.1 Member States' competence in regulatory role

In accordance with Regulation (EC) No 216/2008 (the Basic Regulation) as well as the other regulations and council directives related, the regulatory work on UAS with a MTOM[114] of less than 150 kg falls within the competence of the EU MSs.

Currently in the EU at least 19 MSs have already adopted and implemented, or are currently developing, legislation related to civil UAS. However, an integrated regulation does not exist yet.

Possible levels of rules:

Level	Type (with examples)
1	Constitution
2	Acts and regulations (parliamentary, presidential, governmental)
3	Orders or decrees (ministerial decrees)
4	Decisions, ordinances (self-governing – regional and local level)
5	National Programmes (National aviation safety and security programme
6	Commands (Head of Police)
7	Procedure, SOPs (Surveillance and patrol procedures, search and rescue procedures, etc.
8	Guidelines

Table 7 – Hierarchy of rules

Multilateral or bilateral agreements could fill some gaps but mandatory rules present entitlement for ROBORDER planned activities. The question of the integration and compatibility in the ROBORDER project determines the way the EU MSs would create their own national acts and regulations, Standard Operating Procedures (SOPs) and programmes.

10.4.2 Overview of national specificities

In this chapter a short overview of some MS specificities is provided. Given the fact that this is something already analysed in deliverable D1.5, the overview is maintained short and from a high-level perspective. One can refer to D1.5 for more details.

[113] http://jarus-rpas.org/

[114] Maximum Take-Off Mass

Three MS are analysed in this chapter: Greece, Hungary and Romania. The reason of the choice is that those 3 countries are the ones designated to be organiser of the 3 demonstration workshops, as part of the agreed communication activities of the project.

10.4.2.1 Greece

The Hellenic Civil Aviation Authority (CAA) is a Civil Service under the Ministry for Infrastructure, Transport and Networks, directed by its Governor and Deputy Governors. Its mission is the organization, development and control of the country's air transport infrastructure, as well as the study and laying of proposals to the Minister concerning the overall policy formulation in air transport.

The most recent legal framework for flights of UAS in Greece is the regulation published on 30.09.2016 in the Government Gazette. The purpose of the regulation, as states in Article 1, is to "set out the terms and conditions for operation of Unmanned Aircraft Systems – UAS, free or tethered"

10.4.2.2 Hungary

The Minister for Innovation and Technology (in person) is the authority responsible for transportation. The minister is supported by the Transportation Experts Advisory Board. The laws regulating its activities are clear, transparent, complying with each other as well as with the international regulations.

10.4.2.3 Portugal

Autoridade Nacional de Proteção Civil (ANAC[115]) is the Portuguese Aviation regulatory body exerting functions of regulation, inspection and supervision of the civilian civil aviation sector, with the agreement of the international organization of the European Union, on the basis of the rules governing the regulation of the European Union.

Portuguese laws regulating activities of unmanned civil aircraft systems are clear, transparent, complying with each other as well as with the international regulations.[116]

The Portuguese legal framework comprises the Regulation n. º 1093/2016 of Nov 24th which aims to ensure aviation safety through the adoption of operational standards that allow to face, in a preliminary way, the risks of massive use of this type of aircraft ("Drones"), as well as the operating conditions applicable to the use of Portuguese airspace by remotely piloted civil aircraft systems; and the Decree-Law n. º. 58/2018 of Jul 23th, that came to define rules for the use of unmanned civil aircraft systems in Portugal.

10.5 *Regulations associated with the product and with the sector of activity*

After having described the regulative landscape at an International, European and national level we now focus more on the product itself: unmanned vehicles. This chapter follows the distinction made between the four types of unmanned systems use by ROBORDER system:

[115] ANAC – www.anac.pt

[116] https://www.anac.pt/vPT/Generico/Noticias/noticias2018/Paginas/PressRelease32018.aspx

aerial (UAV), ground (UGV), surface (USV) and underwater (UUV) vehicles. For each class a legal definition and a short overview of current state of regulation are provided.

10.5.1 Unmanned aerial vehicles (UAV)

All different applications require drones to share the airspace with manned aircrafts. However, because the available airspace is already congested and fragmented, huge amounts cannot simply be reserved exclusively to operate RPAS. There is, therefore, a requirement to integrate RPAS into non-segregated airspace lead to increase the number of legal obligations.

The use of robotized swarms in the air represents a great challenge to the legal side of the operations. Additional safety and security issues emerge and give a frame for all activities in a legal environment which changes and transforms quickly and continuously. To transmit, train or instruct those requirements is a joint issue.

The lack of an on-board pilot and smart state-of-art background introduces new considerations with regard to fulfilling safety-related responsibilities such as incorporation of technologies for detect and avoid, command and control, secured communication with ATC, and prevention of unintended or unlawful interference, including cyber threats and direct energy challenges. Security and cyber resilience is a priority area of development to mitigate the risk that UAVs could be subject to malicious or accidental takeovers of data links leading to accidents, theft or deliberate use of the aircraft to damage infrastructures or hurt civilians.

Operating in a wrong and not well-detailed, not regulated ways should lead the operators to a catastrophic situation. Collision in an air-air or air-ground situation is the problem that every operator must avoid at whatever cost.

10.5.2 Unmanned ground vehicles (UGV)

From the perspective of international law, most functions currently assigned to unmanned systems in warfare remain unproblematic. Where legal issues do arise, they are often variations of those associated with manned systems. It is really when unmanned robots are armed that they begin to raise serious legal questions and these concerns intensify with the increasing degree of robotic autonomy in making decisions with regard to the use of force.

10.5.3 Unmanned surface vehicles (USV)

The terminological (and inevitably the legal) line between an unmanned vessel on the one hand and waterborne robots, capsules, torpedoes and buoys on the other is not always clearly drawn. Craft such an underwater robots may sometimes be better considered as part of a ship or part of its equipment, because such things belong by necessity to a (mother) ship.

The question which arise is if maritime law applies to every asset that is used on the seas. In the law of the sea the term is not strictly defined. Numerous conventions dealing with private maritime law are applicable to seagoing vessels and do not provide any definition. Most commentators undoubtedly rightly assume that for the purpose of the law of the sea unmanned vessels must be regarded as ships.[117]

It may be concluded with a considerable degree of certainty that having a crew on board, including a master, is not generally regarded as an essential part of the notion of a ship in the regulatory definitions of the ship available to us. Although some legal doctrine stresses the essential importance of the typically maritime on-board labour community (in addition to the

[117] http://onlinepubs.trb.org/onlinepubs/mb/2017Spring/Pribyl.pdf

technically essential characteristics of a ship), unmanned ships would be covered by the great majority of the existing regulatory definitions and it would appear that the existing conventions and national laws would in principle continue to be functional in respect of these craft.

On the surface the COLREGS (International Regulations for Preventing Collisions at Sea) are a major and ongoing issue as mariners and legislators debate whether unmanned vessels can operate safely in the vicinity of manned vessels. While confidence is building in the wider shipping community a USV platform is required that will do minimum damage to another vessel if a collision should occur. Small, light vessels often with inflatable or foam collars, have tended to be used to prove the unmanned concept. Creating defined sea and waterway areas where unmanned vessels can operate will enable further evaluation of their capabilities.

10.5.4 Unmanned underwater vehicles (UUV)

Unlike air UAVs, i.e. civil aircraft piloted by remote control, UUVs do not have their own regulation and they have attracted less attention from the media, despite their increasing use in tasks such as mapmaking, surveying, maritime rescue and the fight against marine pollution.[118]

Some countries are also increasingly using UUVs for intelligence, surveillance, and reconnaissance (ISR), but even in this field there is no regulation in place. This could cause some serious diplomatic problems, like the one occurred between China and the US in December 2016[119].

10.5.5 Border security systems

The term border security system refers to all frameworks (or platforms) being software, hardware or even both, designed for border security and border surveillance applications. In the competitor analysis (chapter 6) some examples of border security systems more or less similar to ROBORDER are described.

In this section the regulations related to this specific technology are presented, as there are not many holistic systems including all types of unmanned the distinction between unmanned air/ground/water vehicles has been maintained.

The European Defence Agency has developed a flexible way of carrying out research & technology projects in the field of Unmanned Maritime Systems (UMS) for future naval applications. So far 15 projects have been launched in that framework, one of those is the EU Safety and Regulations for European Unmanned Maritime Systems (SARUMS).

SARUMS objective is to provide European Navies a best practice safety framework for UMS that recognises their operational usage, legal status and the needs of navies. The SARUMS group agenda includes workshops but also arranging expert forum conferences.

10.6 *Data management and GDPR*

Regulation (EU) 2016/679, the European Union's new General Data Protection Regulation (GDPR) entered in

[118] http://blog.garrigues.com/en/regulation-of-underwater-drones/

[119] https://thediplomat.com/2017/01/us-china-underwater-drone-incident-legal-grey-areas/

application as for May 2018. GDPR "regulates the processing by an individual, a company or an organisation of personal data relating to individuals in the EU"[120]. The objective is, by setting stronger rules on data protection, for people to have more control over their personal data and for businesses to benefit from a level playing field.

Although many companies have already adopted privacy processes and procedures consistent with the Directive, the GDPR contains a number of new protections for EU data subjects and threatens significant fines and penalties for non-compliant data controllers and processors.

ROBORDER includes a number of technology-oriented WPs that will process both open and closed source data. Data acquired and generated in ROBORDER can be classified as:

- Personal data, which will be used to provide personalized guidelines and decision support including: profile data and data from end-user/user group activity
- Evaluation data, including data used for assuring the functionality of the ROBORDER solution, data collected during the scenarios and pilot use cases to assess the evolution of the users, and data from demonstration and evaluation tasks.

Different measures will be applied depending on the utilization of the gathered data and irrespectively to of the exploitation purposes:

- Data generated in the pilots will be stored in each pilot site based on the security measures specified in the regulation (GDPR);
- End-users will be requested to fill an informed consent form, which indicates the possible usage of their data;
- Files with personal information, including personal data and data collected from the ROBORDER tools, will be protected by means of robust encryption schemes;
- Evaluation results of the pilots will be anonymised, applying the appropriate security measures;
- If material generated is deemed to be EU Classified Material, it will be appropriately marked, protected and accessed by those who require access and have the necessary level of personal security clearance and facility security clearance.

[120] From the European Commission official webpage about GDPR

11 Key Potential Partners for ROBORDER

This section covers the main key partners that have been identified for the ROBORDER project. As stated in the methodology at the beginning, partners are that group of stakeholders which could be interested in the outcomes of the project (as buyers or in any other way), one will see that partners are mainly international and EU organisations and DGs. We have also included a presentation of the partners involved in the regulative part of ROBORDER's project, trying to answer the key questions identified in ROBORDER Sustainability Framework section on key partners (see the figure below).

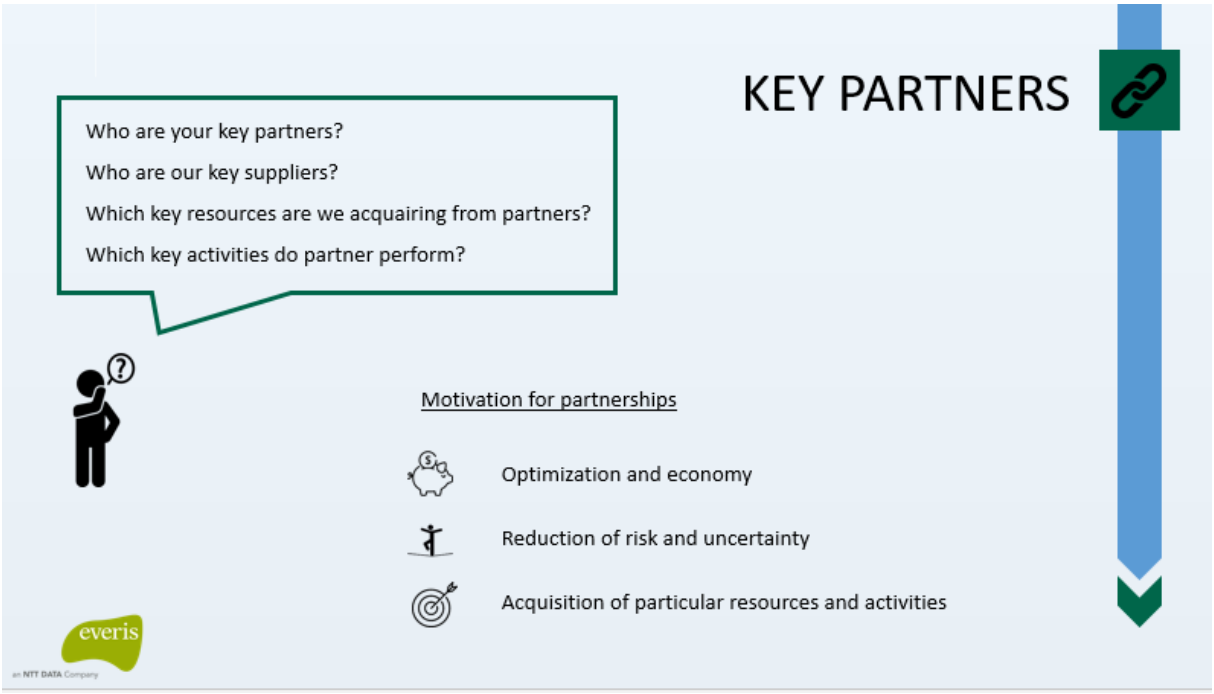

Figure 31 – Key Partners Presentation in the ROBORDER Sustainability Framework

A brief description of the partners and their activity is provided, together with an analysis of their interests in relation to the project and an assessment of the likely impact of ROBORDER on their interests. Key partners include the European Commission, several EU agencies and DGs as well as some international organisations.

11.1 *The European Commission*

The Commission, being the body responsible for proposing legislation and implementing decisions for the EU, is probably the most important actor in all matters concerning drone legislation. During the past years it was engaged in guaranteeing a high level of protection for European citizen in the civil aviation field, by the adoption of common safety rules and by measures ensuring that everyone complies with such rules.

Needless to say, the Commission job is extremly important for ROBORDER outcomes: several relevant legislative actions have already been taken (the main ones are presented in the legal background section of this document) and many others are under way.

11.2 *EU agencies*

11.2.1 EASA

The European Aviation Safety Agency (EASA) is the centrepiece of the EU strategy for aviation safety. Its mission is to promote the highest common standards of safety and environmental protection in civil aviation. The Agency develops common safety and environmental rules at the European level, it monitors the implementation of standards through inspections in the Member States and provides the necessary technical expertise, training and research. The Agency works hand in hand with the national authorities which continue to carry out many operational tasks, such as certification of individual aircraft or licensing of pilots.

EASA regulative activities are of great interest for ROBORDER, especially when it comes to drones. The agency is constantly working at improving the existing but fragmented regulation on UAS operations in the EU and its advancements have to be closely monitored.

11.2.2 Europol

Europol is the official European Union's law enforcement agency, its main goal is to achieve a safer Europe for the benefit of all EU citizens. It supports Member States in their fight against terrorism, cybercrime and other serious and organised forms of crime. They also collaborate with many non-EU partner states and international organisations. In a nutshell, the agency serves as a:

- Support centre for law enforcement operations
- Hub for information on criminal activities
- Centre for law enforcement expertise

Among the many operational areas they are focused on, illegal immigration, smuggling and terrorism are the ones which are most relevant for ROBORDER. The shared interest in those areas could represent a good opportunity to collaborate with Europol, and profit by the expertise and the tools the agency dispose of (the Europol operational centre and their hub for the exchange of criminal data or analysis tools such as the Europol Analysis System)

ROBORDER activities could be interesting for Europol to reach one of their main goals which is to provide the most effective operational support and expertise to investigations in MS by developing and employing a comprehensive portfolio of services. The number of functionalities that ROBORDER system provides could be extremely helpful in their fight against crime and more in particular against illegal immigration, smugglers and terrorist.

11.2.3 Eurocontrol

Eurocontrol is the European Organisation for the safety of Air Navigation, an an intergovernmental civil-military organisation committed to building a Single European Sky that will deliver the air traffic management (ATM) performance required for the twenty-first century and beyond. The agency has agreements with its 41 Member States and with many other countries all over the world.

Eurocontrol has great expertise in air traffic operations and it's also member of the SESAR Joint Undertaking (see dedicated chapter), which means they are making great efforts towards a civil-military ATM coordination. This coordination is extremely relevant for ROBORDER project, which could benefit from a safe integration of drones into the regulated airspace, as it would significantly facilitate UAS operations.

ROBORDER activities, the other way round, could be relevant for Eurocontrol and help them achieve an efficient and rapid integration of drones in the airspace.

11.2.4 Frontex

The mission of Frontex, the European Border and Coast Guard Agency, is to promote, coordinate and develop European border management through several different supporting activities (e.g. identification and fingerprinting of migrants) and by coordination and organising operations on all types of borders, land, air and sea. Cooperation with national autorities, EU partners, internation organisations and non-eu countries is an integal part of Frontex mandate.

Frontex potential cooperation with ROBORDER could span across many of the areas of the agency's operation work, from information exchange and joint operations to research and innovation. In particular when it comes to joint operations at the border, ROBORDER could significantly contribute to Frontex activites and benefit from its support in terms of technical assistance and expertise.

In general, while regular border control is the exclusive responsibility of the Member States, Frontex's operational role focuses on coordination of deployment of additional experts and technical equipment to those border areas which find themselves under significant pressure. In this situation, a system like ROBORDER could really produce benefits to both parties involved: to MS and to Frontex itself.

11.2.5 eu-LISA

eu-LISA is the European Agency for the Operational Management of large-scale IT Systems in the Area of Freedom, Security and Justice. The systems the agency manages (Eurodac, the SISII[121] and VIS[122]) are essential instruments in the implementation of the asylum, border management and migration policies of the EU. Core activities include the operational management of the systems, provision of training, research and development.

The three systems mentioned before all deal with visas, asylum requests and the exchange of information to guarantee the security of the Schengen Area. What eu-LISA could bring to ROBORDER is strategic guidance concerning the implementation and development of its mandate and in particular to the operational management of the IT systems, SIS II in particular as it's the largest information system for public security in Europe.

ROBORDER activities could fit in the core values that drive and underpin operational activities and the strategic development of eu-LISA, in particular it could really help the agency make the best use of their knowledge and experience, contributing to a common success.

11.2.6 Sesar

The SESAR Joint Undertaking is the mechanism which coordinates and concentrates all EU research and development (R&D) activities in ATM and

[121] The second generation Schengen Information System

[122] The Visa Information System

the technological pillar of Europe's ambitious Single European Sky (SES) initiative. The objective of SESAR is modernise European ATM by defining, developing and delivering new or improved technologies and procedures (SESAR solutions). A total of 100 organisations are actively participating in and demonstrating the impact of the programme today.

One of the 4 key areas in which SESAR focus on is air traffic services, one of the most relevant project is this area is U-space. The project is working at a framework at EU level, which would allow the creation of a truly European market for drone services and aircraft. Many actors could benefit from the future U-space, the ROBORDER project itself included.

For SESAR to reach its full potential, it needs the expertise of all stakeholders and the assurance that the technologies developed will meet their needs. That's why the SESAR Joint Undertaking continually strives for including more experts or stakeholders into the programme and its committees, and that represents a great opportunity for the ROBORDER project.

11.2.7 EDA

The European Defence Agency (EDA) is an intergovernmental agency of the Council of the European Union with a triple mission: supporting the development of defence capabilities and military cooperation among MS, stimulating defence Research and Technology (R&T) and strengthening the European defence industry, acting as a military interface to EU policies.

In order to maximise the effectiveness of its work, the Agency works closely together with a number of EU institutions, international organisations and third States. Several Administrative Arrangements with international organisations and third States have also been concluded.

EDA represents a very important partner for ROBORDER, as it's the major actor of the defence and security market at EU level and closely work with the Commission in drafting directives and for policy matters. Furthermore, a close collaboration should be established with other key partners of the project, such as EASA and SESAR. For instance, EDA is currently working in the RPAS field with EASA (harmonisation of civil and military rules and regulations to enable safe operations in Europe).

11.3 *DGs*

11.3.1 DG Migration and home affairs (HOME)

The EU is committed to increase cooperation on cross-border issues, such as asylum, migration, border control, organised crime and terrorism. The Directorate-General Migration and Home Affairs prepares EU-level rules in these policy areas and watches over their application. DG HOME also collaborates to some decentralised EU agencies such as Frontex, Europol, CEPOL[123], eu-LISA and organises and supports networks (e.g. EMN[124]) where the members can exchange views and information on specific Home Affairs policies.

[123] The European Union Agency for Law Enforcement Training

[124] European Migration Network (EMN)

DG HOME is directly involved in the fight against terrorism and organised crime, by promoting police cooperation and by preparing to swiftly respond to emerging crises. This fight is strictly linked to the broader European Security Strategy, which aims at strengthening cooperation on law enforcement, border management, civil protection and disaster management. ROBORDER added value could potentially bring some benefits to the European security strategies and that is the reason why DG HOME can be considered as an important key partner for the future outcomes of the project.

11.3.2 DG Mobility and transport (MOVE)

The European Commission's Directorate-General for Mobility and Transport works in concert with the EU Member States, European industry, citizens and stakeholders and is in charge of developing transport policies for the EU. DG MOVE carries out its tasks in many different ways and it's assisted in its work by different expert inputs mainly EU agencies (e.g. EASA[125], EMSA[126]…) and Joint Undertakings (SESAR, Shift2Rail).

Among the different transport modes probably the most relevant, from a ROBORDER perspective, is air transportation. This a strategically important sector for the DG, which is involved in several aspects for EU skies: the aviation strategy for Europe, the Single European Sky (SES) and the SESAR initiative as well.

DG MOVE, together with the European Commission is working at setting new standards to regulate the operations of RPAS, which will cover safety, security, privacy, data protection, insurance and liability. The aim is to allow European industry to become a global leader in the market for this emerging technology, while at the same time ensuring that all the necessary safeguards are in place.

11.4 *International organisations*

11.4.1 ICAO

The International Civil Aviation Organization (ICAO) is a UN specialized agency, established to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention). It is one of the most important players in the aviation field. ICAO works with its 191 Member States and with the industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

ICAO produces global plans to coordinate multilateral strategic progress for safety and air navigation and also monitors and reports on numerous air transport sector performance metrics. Even though it takes care of aviation high-level standards, it remains an important stakeholder for the ROBORDER project.

11.4.2 JARUS

[125] European Aviation Safety Agency (EASA)

[126] European Maritime Safety Agency (EMSA)

JARUS is a group of experts gathering regulatory expertise from all around the world. At present, 54 countries, as well as EASA and Eurocontrol, are contributing to the development of JARUS work products. The purpose of JARUS, as stated in their Terms of Reference[127], is "to recommend a single set of technical, safety and operational requirements for all aspects linked to the safe operation of the Remotely Piloted Aircraft Systems (RPAS).

The group does not develop industry standards (like ICAO) but it's constantly reviewing existing regulations and other material applicable to unmanned systems. JARUS ultimate goal is the integration of RPAS into the present manned aircraft environment, which is a very important precondition for maximising ROBORDER system functionalities.

11.4.3 FAA

The Federal Aviation Administration (FAA)[128] of the United States is a national authority with powers to regulate all aspects of civil aviation. These include the construction and operation of airports, air traffic management, the certification of personnel and aircraft, and the protection of U.S. assets during the launch or re-entry of commercial space vehicles.

[127] JARUS terms of reference http://jarus-rpas.org/sites/jarus-rpas.org/files/imce/attachments/jarus_tor_v06.17_with_annex_tor_of_scb_0.pdf

[128] The Federal Aviation Administration https://www.faa.gov/

12 Conclusion and ROBORDER Value Proposition

A value proposition states the specific benefits a product or service offering provides to buyers, it shows why the product or service is superior to competing offers[129]. The value proposition is the answer to a very simple question: "Why should I buy from you?". As such, it becomes a critical component in shaping strategy.

In this chapter ROBORDER value proposition is developed starting from a few basic questions taken from the business model canvas (see methodology chapter for more details): what value we deliver to the customers, which problems are we trying to solve, what needs we are satisfying and what are we offering to do that.

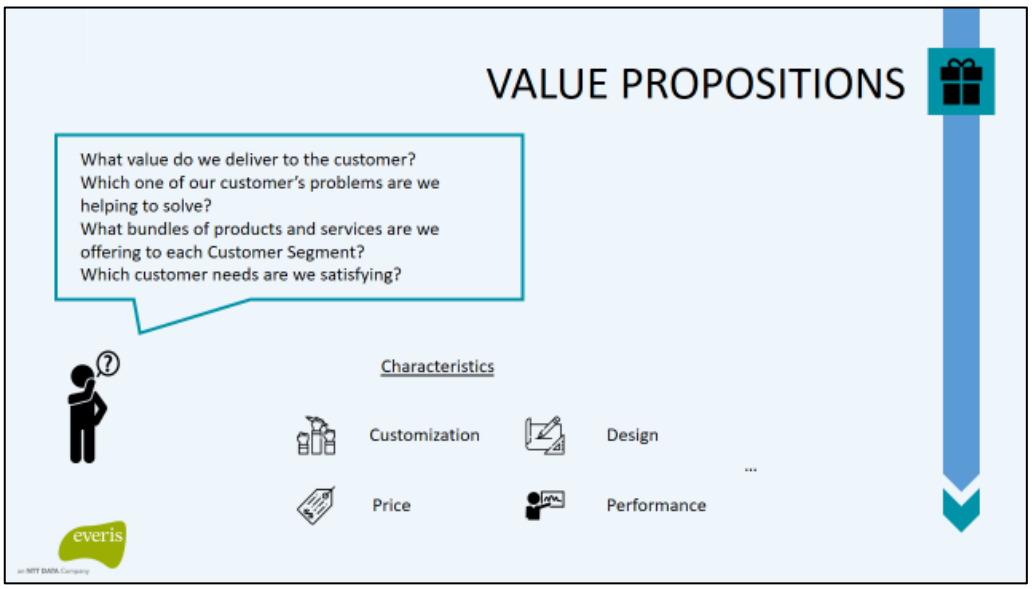

Figure 32 – Overview of the value proposition area of the business model canvas

ROBORDER customers (LEAs, Border Agencies and governments more in general) have to face a number of problems when it comes to patrolling countries' external borders.

- One of the main problems is the increasing heterogeneity of threats (terrorism, illegal trafficking, migration from both land and sea borders),
- The adverse conditions (weather or morphology of the territory) which make it dangerous or very difficult to reach some areas represent another relevant problem,
- Furthermore, the current approach adopted by MS is not always reliable, often costly and resource intensive (in terms of manpower and infrastructure).

ROBORDER system is offering to those customers a holistic solution for border surveillance integrating a swarm of unmanned vehicles with a network of multimodal sensors, static or mounted on board of the vehicles themselves. In addition, several supplementary technologies are applied in order to establish robust communication links between robots and command and control units, to detect different types of threats, to analyse the large volume of data collected and to provide effective and rapid support for decision making.

[129] https://open.lib.umn.edu/principlesmarketing/chapter/2-1-the-value-proposition/

ROBORDER solution satisfies all main customer needs[130]:

- It offers technologies capable of adapting to different operational and environmental needs (high flexibility with high efficiency)
- It allows and foster interoperability with existing infrastructures (fully modular system)
- It is capable of operating autonomously, to analyse data and compile a tactical picture for better decision making (detection and response within minutes)

Solving customers' problems and satisfying their needs is the source of ROBORDER added value, which we try to resume with the following table[131]:

Characteristics to cover	ROBORDER added value
Newness	Provide an overall order security solution, integrated with current systems and effective for both maritime and land borders.
Performance	Enables efficient and effective operation of heterogeneous multi-asset system by a single operator. Enables response to threats within minutes.
Customization	Designed to take advantage of the variety of available UxVs for high system flexibility and re-configurability, which allows it to serve a wider range of use-cases and scenarios more efficiently.
"Getting the job done"	The platform should be facilitating the decision making and contributing to the digitalisation of the services for security and border patrolling.
Design	A system co-designed with end users by crossing the boundaries of many disciplines related to the surveillance of borders (border authorities, LEAs, end-users, scientists, industry and SMES and international organisations).
Brand/status	To be created
Price	To be defined
Cost reduction	Lower cost than traditional surveillance methods at several levels (ownership cost, personnel training, maintenance and other operations costs). Also reduce the cost opportunity of having personnel and provision in surveillance points where there aren't incidents.
Risk reduction	Software tools assisting the short-term prediction of the spatial evolution of either border related hazard pollution phenomena or illegal activities, which allows ROBORDER to early identify any change of the ongoing incidents

[130] analysed throughout the study, see Key Trends section and Key activities chapter.

[131] the characteristics to cover are taken from the business canvas model mentioned in the methodology chapter

Accessibility	?
Convenience/usability	By enabling the highly autonomous cooperation between the different types of robots and sensors it enables the operators to easily command and control the assets by keeping their cognitive load to the minimum and without the need to get involved into tedious and mundane activities

Table 8 – Summarising overview of ROBORDER added value

Finally, ROBORDER's value is strengthened by the fact it matches the technical requirements and user needs we collected from the end user questionnaire.

To conclude, there is a strong market opportunity for ROBORDER. As preliminary SWOT analysis shows in the picture below, there have been several aspects analysed in the market analysis and the main conclusions are summarised in it regarding ROBORDER system's strengths, weaknesses, opportunities and threats. As market analysis is going to be integrated in following Business Plan and Exploitation and Long-term Sustainability deliverables, the document is perceived background and preliminary study to achieve the project goals.

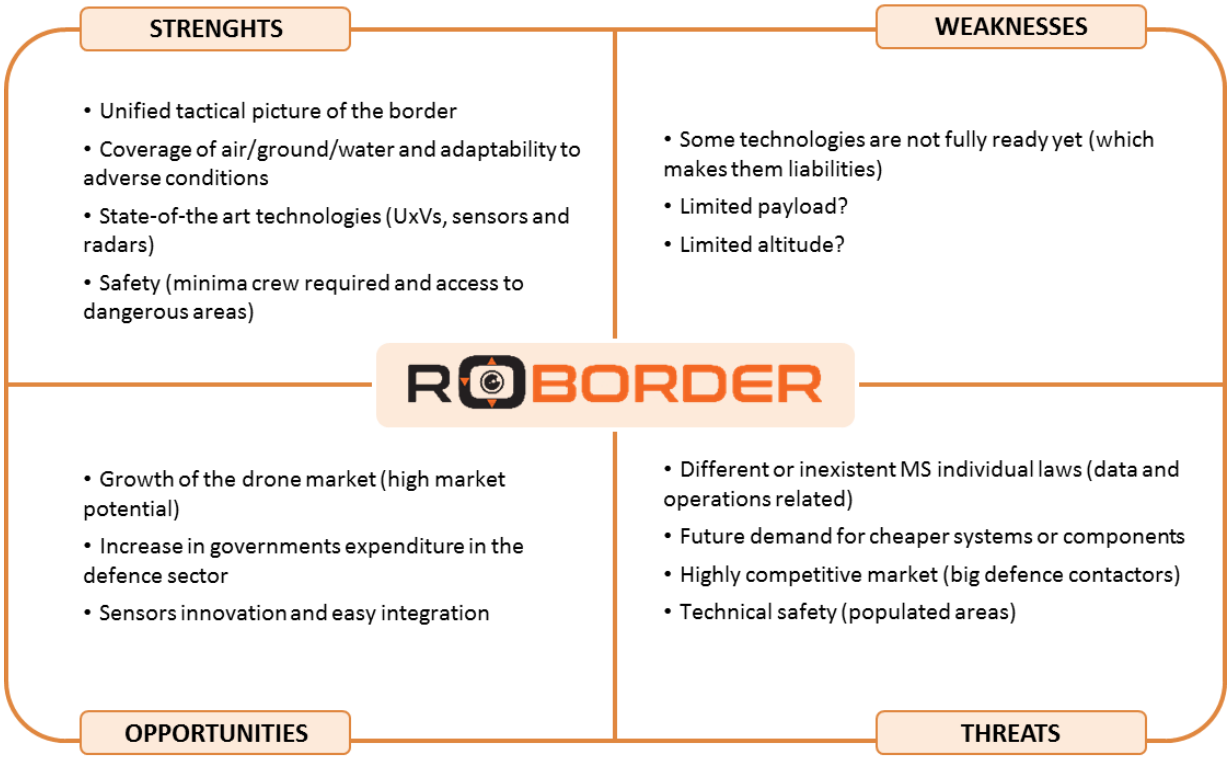

Figure 33 – Preliminary ROBORDER SWOT analysis

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https://www.baesystems.com/en/home
https://www.thecyberhawk.com/
https://enterprise.dji.com/
http://www.ehang.com/
https://hoverflytech.com/
https://www.intel.com/
http://global.parrot.com/usa/
https://www.precisionhawk.com/
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https://www.futuremarketinsights.com/reports/ultralight-aircraft-market
https://www.businesswire.com/news/home/20180412005748/en/Global-Electric-Aircraft-Market-Report-2018-2023--

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http://www.flir.eu/home/
http://xenics.com/en
https://www.thermal.com/
http://www.thermoteknix.com/
http://www.c-thermal.com/
http://www.instro.com/

Official websites of software vendors

https://www.3ds.com/
https://www.ptc.com/
https://www.ettus.com/
https://www.sap.com/industries/defense-security.html
https://enterprise.microsoft.com/en-us/industries/government/national-security-and-defense/
https://www.hcltech.com/
https://www.zte.com.cn/global/
http://www.huawei.com/en/?ic_medium=direct&ic_source=surlent
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https://www.gd.com/
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Companies' official websites (competitors)

Key partners - Agencies, DGs and organisations official websites

Other deliverables and internal docs:

- Grant Agreement
- Technological Roadmap
- Legal Compliance Requirements Analysis