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RAdars for loNG distance maritime surveillancE and Search and Rescue opeRations

MARKET ANALYSIS

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Executive summary

This document presents the outcomes of the market analysis. The market itself is a polysemous and contested term. Market mean different things to different people. So does terms such as customer, end-user, stakeholder etc. This deliverable thus tries to encompass market analysis as a whole: it first introduce the market as geographical areas. Then after, the deliverable moves to presenting organisations, before widening the *ye olde* buying-selling concept into thinking of different business models and ecosystems. Finally the most pivotal countries are presented and analysed with pros and cons, before introducing existing competitors. By presenting the competitors, the RANGER value comes more visible: an integral part of any project's desirable outcome.

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1 Introduction

1.1 Purpose of the Document

The famous Merriam-Webster dictionary gives two category of entries to the word "Market". First, describes it to be for example, "a meeting together of people for the purpose of trade by private purchase and sale and usually not by auction" and "a public place where a market is held, especially a place where provisions are sold at wholesale". Market can be also of a specified kind. Or, simply the act or an instance of buying and selling, but also, the rate or price, a geographic area, a specified category of potential buyers, and also, an opportunity for selling. Thus, the second category implies that market is a verb: to expose for sale in a market and to sell.[1]

In this Market Analysis we try cover a bit of all above. First, we examine the various regions of markets, stakeholders and business models both for the integrated RANGER solution and for its various components in EU. The focus of analysis is on various maritime surveillance (MS) activities. Other markets than MS are also discussed shortly in the context of alternative business models and opportunities. However, non-civilian use of RANGER is excluded. The Market Analysis will include an analysis for RANGER for the priority markets areas whether they are geographical or related to specific potential buyers. Thus, this deliverable pinpoint the opportunities for selling. However, the work cannot be understood as a manual for a salesperson. Rather it aims at reveal the potential that RANGER has. Therefore, in this deliverable, a considerable amount is put into analysing potential competitors. By doing that, the value of RANGER can be demonstrated.

1.2 Structure of the document

In this deliverable, we will first shortly describe what could be the role of RANGER solution in various regions and countries in EU, and focus in the MS activities (Chapter 2). After that, we will identify current players of MS in EU, whose role might be either end-users, paying customers, or partners.

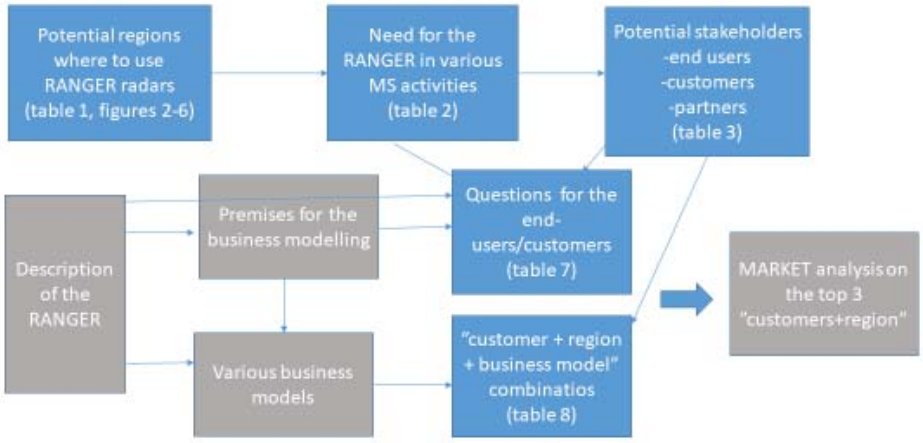

Figure 1: The Process for the Market Analysis

In Chapter 3, will be then describe the RANGER solution and its various component. This is to give the reader a fuller understanding of the RANGER solution. However, it is not the complete description of RANGER: other deliverables are explaining e.g. technicalities far more detailed. Understanding RANGER is pivotal also for the latter chapters on the competitors and alternative solutions: without knowledge on RANGER solutions, it is impossible to judge its value. Before going into the competitors, in Chapter 4, will first identify various premises for the business modelling from customers' and society's point of view. Then in Chapter 5, the focus is moved on the technology provides point-of-view and identify "business modelling + customer + region" options based on the previous information. Finally, in Chapter 6 we will provided an analysis on

[1] Merriam-Webster dictionary. *Market.* At https://www.merriam-webster.com/dictionary/market

selected countries and/or regions. Then, as described earlier, the final chapters will go into a presentation and comparison of main competitors' solution, and present the added value of RANGER.

2 Maritime Surveillance Market in General

2.1 Defining Maritime Surveillance

Maritime surveillance is essential for creating maritime awareness, "knowing what is happening at sea". This awareness assists the authorities responsible for monitoring and surveillance activities in preventing and managing in a comprehensive way all situations, events, and actions related to the EU maritime domain. (COM 2009)

Maritime surveillance includes various aspects and different kind of user communities. The user-groups defined in the left column of the table are the same as the CISE user communities[2] (see e.g. COM 2010) complemented with the user groups identified in the green paper "Offshore activities of coastal EU member states and cross-border cooperation"(COM 2007).

According to the RANGER GA, the main focus in RANGER project is in border control and in search and rescue operations. However, the other aspects of MS are reasonable to take into account as potential users and stakeholders of the same RANGER technology installed in the area.

The MS activities where RANGER could be used are described in the right column of the table, originally defined in the RANGER ethics deliverable D3.2 (RANGER 2017).

Aspects of maritime surveillance	**Value of RANGER**
Maritime safety, maritime security (and vessel management)	Improving safety and efficiency of marine vessel traffic Search and rescue (SAR) early warning/identification Terrorism early warning/identification Port security
Border control & surveillance	Early warning/identification of irregular immigration Early warning/identification of human trafficking
Fisheries control	Early warning/identification of illegal, un-reported/-regulated fishing (>wrong area, wrong time, wrong equipment, exceeding fishing quotas) Monitoring fish nets/fish traps
Customs	Early warning/identification of vessels smuggling illegal goods Early warning/identification of vessels smuggling legal goods
Environment (including pollution response)	Early warning/identification of vessels causing oil spills and/or unleashing wastewater Monitoring of protected areas
General law enforcement	Monitoring of compliance with applicable legislation in sea areas, where there is a policing competence and support to enforcement and/or response operations.

Table: 1 Aspects of maritime surveillance and RANGER.

Value of RANGER needs to be expressed, since any attempt to enter a market must start from the very basic justification of existence: why RANGER, what values does it bring to the customers and larger to the society.

2.2 Potential target regions for the integrated RANGER solution for MS operations in EU countries

Potential end-users of RANGER in maritime surveillance (MS) are those, who already have radar at their use for their MS operations. The obvious reason for this can be derived from

functionalism[3]: since something exist, it needs to have a reason. Thus put in practice, those who have radars have purchased them for a reason, and they are therefore the most potential for enhancing radar capabilities. Furthermore, many operate in areas where there is a need of enhanced MS surveillance capacity. In EU potential end-users can be state actors, regional bodies, even municipalities.

According to RANGER GA (part A), the primary market sector is the maritime border security organisations in Europe. In particular, current external border control and surveillance measures have proven to be inadequate in preventing illegal immigration through the Mediterranean Sea and the Atlantic Ocean between Africa and the Canary Islands. (RANGER GA 2017). These areas refer to the regions of M1-M6 and A1 in the tables 2 and 3.

In the Table 2, here below, are presented the various potential geographic areas of the Mediterranean Sea, the Baltic Sea, the North Sea, and the parts of the Atlantic Ocean where RANGER could bring value for the MS operations. The areas are visualised as maps in the Annexes.

Area	Description	EU countries	Other countries
Mediterranean Sea			
Area M1	Gibraltar area (West Mediterranean)	Spain	Morocco, Algeria
Area M2	Balearic Sea and west of Corsica and Sardinia	Spain, France, Italy	Algeria
Area M3	Tyrrhenian sea	Italy, Malta	Tunis, Libya
Area M4	Coast of Libya and South Italy	Greece, Malta, Italy	Libya
Area M5	East Mediterranean	Greece, Cyprus	Egypt, Syria, Turkey, Lebanon
Area M6	Adriatic Sea	Italy, Croatia	Albania, Montenegro, Bosnia-Herzegovina
Baltic Sea			
B1	Gulf of Botnia (north)	Sweden, Finland	
B2	Gulf of Botnia (south)	Sweden, Finland	
B3	Gulf of Finland	Finland, Estonia	Russia
B4	Area north of Gotland	Sweden, Latvia, Estonia, Lithuania	
B5	Southern part of Baltic Sea	Denmark, Germany, Lithuania, Poland, Sweden	Russia
Atlantic Ocean			
A1	Azores	Portugal	Morocco
A2	Bay of Biscay	France, Spain	
A3	Canary Islands and Madeira	Spain, Portugal	Morocco, West Sahara
A4	The French "Dom-Tom[4]"s and other overseas countries and territories of the EU	France, Netherlands	US
A5	North Sea	Denmark, UK, Germany, Netherlands, Belgium, France	Norway
A6	Arctic Ocean		
Black Sea			
BS1	Black Sea	Bulgaria, Romania	Russia, Ukraine, Georgia, Turkey.

[3] See Émile Durkheim.

[4] This refers to, for example, the Overseas France (in French: France d'outre-mer) that consists of all the French-administered territories outside the European continent, mostly relics of the French colonial empire. The Netherland has too so-called overseas countries and territories of the European Union: the islands of Bonaire, Sint Eustatius and Saba in the Caribean Sea.

Table 2: Regions where RANGER could bring value/benefit

Table 3 further identifies those areas of maritime surveillance operations that are likely to benefit from the enhanced RANGER maritime surveillance capabilities. The priority areas defined in RANGER GA are marked as yellow.

Maritime Security challenge:	Border Control	Customs	SAR	Environment	Other
Mediterranean					
M1 Gibraltar area	immigration	Drug trafficking			
M2 Balearic Sea	immigration	Drug trafficking	leisure boats on summer	oil spills	systematic robbery
M3 Tyrrhenia	immigration	Drug trafficking	irregular immigrates on the sea	waste dumping	systematic robbery
M4 Coast of Libya	immigration	Drug trafficking	irregular immigrates on the sea	waste dumping	illegal fishing
M5 East Med.	immigration	Drug trafficking	irregular immigrates on the sea	waste dumping	illegal fishing
M6 Adriatic Sea		Drug trafficking	leisure boats on summer		
Baltic Sea					
B1 Gulf of Botnia (north)			Commercial and leisure traffic	Oil spills, Waste dumping,	Sea blooms
B2 Gulf of Botnia (south)			Commercial and leisure traffic	Oil spills, Waste dumping	illegal fishing, Sea blooms
B3 Gulf of Finland			Leisure traffic	Oil spills, Waste dumping	Sea blooms
B4 North of Gotland			Commercial and leisure traffic	Oil spills, Waste dumping	Sea blooms
B5 South Baltic		Drug trafficking	Commercial and leisure traffic	Oil spills, Waste dumping	Sea blooms
Atlantic Ocean					
A1 Azores		Drug trafficking	commercial traffic		illegal fishing
A2 Bay of Biscay		Drug trafficking	Commercial and leisure traffic	oil spills	illegal fishing
A3 Canary Islands and Madeira	Immigration	Drug trafficking	Irregular immigrates on the sea. Commercial and leisure traffic		illegal fishing
A4 "Dom-Tom"s		Drug trafficking	Commercial and leisure traffic	oils spills	illegal fishing
A5 North Sea		Drug trafficking	commercial and leisure traffic	oil spills	
A6 Arctic Ocean			commercial ship traffic + flight routes	oil spills (oil drilling)	
Black Sea					
BS1 Black Sea					

Table 3: Regions and their MS activities in need of enhanced MS surveillance capacity

These tables above can serve as a starting point of any analysis in order to discover the potential users and/or buyers for RANGER. In the next Chapters, the potential will be narrowed down into more concrete entities by examining the responsibilities and functions too.

2.3 Key actors in MS market in EU

2.3.1 Key MS actors in various countries

In the tables below are identified various MS authorities in various counties. It is notable that these actors can have roles of both end-users, paying customers and other stakeholders. The information

is from working document of DG Fisheries and Maritime Affairs/Maritime Policy Task Force. (COM 2007)

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
GREECE	Ministry of National Economy and Finance /Customs	-Ministry of Merchant Marine/Hellenic Coast Guard -Hellenic Navy (contribution when needed) - Ministry of Public Order/Hellenic Police (on matters relating to the reception of migrants and granting of asylum)	Ministry of Merchant Marine/Hellenic Coast Guard	-Ministry of Merchant Marine/Hellenic Coast Guard -Ministry of Rural Development and Foods (policy only)	Ministry of Merchant Marine/Hellenic Coast Guard	Ministry of Merchant Marine/Hellenic Coast Guard	Ministry of Merchant Marine/ Hellenic Coast Guard	-Ministry of Merchant Marine/Hellenic Coast Guard -Ministry of Merchant Marine/Civil Emergency, Planning and Defence Directorate	-Ministry of Merchant Marine/Hellenic Coast Guard -Hellenic Navy and Air Force (when needed)	Ministry of Merchant Marine/Hellenic Coast Guard

Table 4: Greek MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
ITALY	Ministry of Economy and Finance/Customs	-Ministry of Transport/Italian Coast Guard (when a SAR operation is also needed) -Ministry of Interiors/Police Forces -Ministry of Defence/ Navy - Ministry of Economy and Finance/Customs	-Ministry of Environment, Territory and Sea -Coast Guard	-Ministry of Agricultural Policies - Coast Guard (National Fishing Control Centre) -Navy	Ministry of Transport/Coast Guard	-Ministry of Transport/Coast Guard	-Ministry of Transport/Coast Guard	State Civil Defence Department/Sea Emergency Operations Centre (manned with personnel of the Coast Guard	Ministry of Transport/ Coast Guard	Ministry of Transport/Coast Guard -Ministry of Interiors/Police Forces -Ministry of Defence/Navy

Table: 5 Italian MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
FRANCE	Customs (Ministry of Finance)	-Navy -Customs - Ministry of Transport/ Administration of Maritime Affairs -Customs -Ministry of Interior (home office)	-Ministry of Environment -Ministry of Transport/ Admin. of Mar. Affairs -Ministry of Justice -Customs -Ministry of Interior (home office-civil protection)	Ministry of Agriculture - Ministry of Transport/ Admin. of Mar. Affairs -Ministry of defense /Navy/gendarmerie -Ministry of Finances/Customs/ Concurrence et repression des fraudes	-Ministry of Transport/ Admin. of Mar. Affairs	-Ministry of Transport/ Admin. of Mar. Affairs	Ministry of Transport/ Admin. of Mar. Affairs	-Ministry of Transport/ Admin. of Mar. Affairs -Navy -Ministry of Interior (home office-civil protection)	-Ministry of Transport/ Admin. of Mar. Affairs -Navy -SNSM -Ministry of Interior (home office-civil protection)	-Ministry of Transport/ Admin. of Mar. Affairs -Navy -Customs -Gendarmerie

Table: 6 French MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
PORTUGAL	-Ministry of Justice/ Judiciary Police -Ministry of Finance/ Customs and Special Duties General Administration -Ministry of Home Affairs/ Fiscal Brigade	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force - Ministry of Home Affairs/ Aliens and Border Service	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force	-Ministry of Agriculture, Rural Development and Fisheries -System of Supervision and Fishing Activity Control (SIFICAP) -Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force -Ministry of Home Affairs/ National Republican Guard	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force -Ministry of Public Works, Transports and Communications	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force -Ministry of Public Works, Transport and Communications	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force -Ministry of Public Works, Transport and Communications	-Ministry of National Defence / National Maritime Authority-Portuguese Navy -Ministry of Public Works, Transport and Communications	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force -Ministry of Public Works, Transport and Communications	-Ministry of National Defence /National Maritime Authority-Portuguese Navy/Air Force -Ministry of Home Affairs/National Republican Guard/Aliens and Border Service

Table 7: Portuguese MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
SPAIN	-Ministry of Interior _Tax Agency	-Ministry of Interior	-Ministry of Infrastructure -Ministry of Environment - Coastal Autonomous Communities	-Ministry of Agriculture, Fisheries and Food -Ministry of Interior - Coastal Autonomous Communities (in internal waters)	-Ministry of Infrastructure	-Ministry of Infrastructure -Ministry of Interior	-Ministry of Infrastructure	-Ministry of Environment -Ministry of Infrastructure -Coastal Autonomous Communities	-Ministry of Infrastructure (SASEMAR)	-Ministry of Interior -Ministry of Defence

Table 8: Spanish MS key authorities

Member- States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
MALTA (policy formulation)	Ministry of Finance	- Armed Forces of Malta - Police	- Malta Maritime Authority - Ministry of Rural Affairs and Environment (Malta Environment & Planning Authority has a monitoring role)	Ministry of Rural Affairs and Environment/Fisheries Conservation & Control Division	Malta Maritime Authority	- Malta Maritime Authority - Armed Forces of Malta	Malta Maritime Authority	- Malta Maritime Authority -Armed Forces of Malta - Civil Protection Department	Armed Forces of Malta	Police
(policy implementation)	Customs Department	- Armed Forces of Malta - Police	-Malta Maritime Authority - Oil Pollution Response Module (OPRM) - Civil Protection Department	Ministry of Rural Affairs and Environment/Fisheries Conservation & Control Division.	Malta Maritime Authority	- Malta Maritime Authority (within ports) - Armed Forces of Malta (coastal security) - Police	Malta Maritime Authority (Ports VTS) Armed Forces of Malta (Coastal VTS)	-Civil Protection Department (with the coordination of the Police, the Armed Forces of Malta and the Malta Maritime Authority)	-Armed Forces (with the coordination of the Police and the Civil Protection Department)	Police

Table 9: Maltese MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
CYRPUS	Dpt. Of Customs	Marine Police	Dpt. For Fisheries and Marine Research / Dpt. of Merchant Shipping	Dpt. For Fisheries and Marine Research	Dpt. of Merchant Shipping	Dpt. of Merchant Shipping / Marine Police / Cyprus Ports Authority	Dpt. of Merchant Shipping / Cyprus Ports Authority	Dpt. of Merchant Shipping / Marine Police / Civil Defence Service	Dpt. of Merchant Shipping / Ministry of Defence	Ministry of Justice & Public Order (Police) / Dpt. of Merchant Shipping

Table 10: Cypriot MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
GERMANY	Federal Ministry of Finance	Federal Ministry of Interior	Within Territorial Waters and Shore Areas: Ministries of Environment of the Coastal States	Federal Ministry of Food, Agriculture and Consumer Protection	Federal Ministry of Transport, Building and Urban Affairs	Federal Ministry of Interior and Coastal States and Federal Ministry of Transport, Building and Urban Affairs and Federal Ministry of Defense* Federal Police and Water Police and Point of Contact	Federal Ministry of Transport, Building and Urban Affairs	Federal Ministry of Transport, Building and Urban Affairs and Coastal States	Federal Ministry of Transport, Building and Urban Affairs but also Ministry of Defense*	by each responsible Ministry
	Federal Customs Administration	Federal Police	Outside Territorial Waters: Federal Ministry of Transport, Building and Urban Affairs	Federal Agency for Agriculture and Food	Federal Waterways and Shipping Administration but also Federal Maritime and Hydrographic Agency and See-Berufs-genossenschaft		Federal Waterways and Shipping Administration	Central Command for Maritime Emergencies – CCME (Joint organization)	German National Lifeboat Association but also German Navy*	by each responsible Authority, mainly Federal Waterways and Shipping Administration
			Federal Waterways and Shipping Administration and CCME; Environmental Authorities of the Coastal States							
	Water Customs Service	*Federal Police*	*Federal Waterways Services*	*Fishery Control*		*Federal Police; Water Police* *Federal Maritime and Hydrographic Agency* *German Navy**	*Vessel Traffic Services*	*Joint Emergency Reporting and Assessment Centre*	*Maritime Rescue Co-ordination Centre* *Helicopters by German Navy and Federal Police*	*by each responsible body*
	***Network German Coast Guard**:* *The command centres of the Federation and the Coastal States including the Maritime Emergencies Reporting and Assessment Centre are operating together in the **Joint Emergency Reporting and Assessment Centre** under the roof of the **German Safety and Security Centre** in Cuxhaven. Each agency retains the same responsibility in terms of geographical area and tasks as before, but information exchange, co-operation, co-ordination of operational means and support are optimized (see annexed figure).* *In case of emergency situations the authority competent in the case will lead operations.* **Role of the **German Armed Forces**:* The German Armed Forces have the task to provide national security and defense against any threat from outside enemies. In accordance with a recent Supreme Court ruling concerning the Aviation Security Act, protection against imminent terrorist attacks may be considered as grave threats to security and the Armed Forces may act to prevent such threats in accordance with the German Constitution (Art. 35). In particular it is the task of the German Armed Forces to monitor all German Air and Water Space and to support other agencies in exercising sovereign rights. Rescue operations, evacuation operations and surveillance missions are also within the scope of tasks of the German Armed Forces.									

Table 11: German MS key authorities

Member - States	Customs	Border control	Pollution response and prevention	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
FINLAND	Policy: ministry of finance Operational aspects: Customs Authorities (=The Finnish Customs), the Border Guard (immigration)	Policy: ministry of the Interior, Operational aspects:Bor der Guard with coast guard districts, Policy related to maritime surveillanc e: ministry of Defence, operational aspects: Navy	**Policy:** Ministry of the Environment **Operational aspects:** Finnish Environmental Institute (in co-operation with the Navy, the Border Guard, Finstaship (=state-owned shipping company), and the local rescue authorities) **Pollution prevention:** Ministry of the Environment, Ministry of Transport and Communication, Ministry of Agriculture and Forestry	Policy matters: Ministry of Agriculture and Fishery, Operational aspects / controlling: - Fisheries units at the Employment and Economic Development Centres, police, Finnish border guard, the Finnish customs	Policy: Ministry of Transport and communications, operational aspects: Finnish Maritime Administration, PLS NOTE: the ministry of social affair s and health is responsible for the working conditions onboard the ships and respective inspections carried out by industrial safety administration	Policy: ministry of Transport and communications, operational aspects: Finnish Maritime Administration, in case of military crisis or war, the task of the Finnish Navy is to protect maritime traffic and transport	Policy: ministry of Transport and communications, operational aspects: Finnish Maritime Administration	Operational aspects: Finnish Maritime Administration, Finnish Border Guard (at sea), Rescue departments (harbours), the Finnish Environment Institure	Operational aspects: Border Guard is responsible, the Finnish Navy conducts maritime SAR operations with and under the Border Guard	Finnish Border Guard,Police, Finnish Customs

Table 12: Finnish MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
DENMARK	-Ministry of Justice -Customs Authority - Admiral Danish Fleet and Naval Home Guard may be used to embark Customs officers at sea	-Ministry of Refugees, Immigration and Integration Affairs - Local Police districts - Admiral Danish Fleet will provide maritime surveillance and enforce national sovereignty at sea	- Danish Environmental Protection Agency (law) - The Admiral Danish Fleet is responsible for the maritime – anti-pollution response - Local municipalities when pollution reaches the shore	Ministry of Food, Agriculture and Fisheries - the Danish Directorate of Fisheries	Danish Maritime Authority	-Ministry of Defense - Danish Coastal Authority - Danish Maritime Authority - Ministry of Transport and Energy (ports)	- Danish Maritime Authority - Admiral Danish Fleet	- The Emergency Response Committee (consists of the Danish Energy Authority (chair), the police in Esbjerg, the Admiral Danish Fleet, the Danish Environmental Protection Agency and the Danish Maritime Authority) supervises all measures taken by the operating company in case of a major accident on an offshore installation - Admiral Danish Fleet - Danish Maritime Authority	Royal Danish Navy	- Ministry of Justice and local police districts - Danish Authority for Enterprise and Construction (rules on dual use products) - Admiral Danish Fleet -Customs Authority and Danish Maritime Authority may provide the legal basis for law enforce-ment - Ministry of Transport and Energy

Table 13: Danish MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
SWEDEN	*Policy:* - Ministry of Finance *Operational:* - Swedish Customs - Coast Guard	*Policy:* - Ministry of Justice *Operational:* - Coast Guard	*Policy:* - Ministry of Enterprise, Energy and Communications - Ministry of Defence *Operational:* - Environ mental Protection Agency - Coast Guard	*Policy:* - Ministry of Agriculture *Operational:* - Swedish Board for Fisheries - Coast Guard	*Policy:* - Ministry of Enterprise, Energy and Communications *Operational:* - Swedish Maritime Administration - Coast Guard	*Policy:* - Ministry of Enterprise, Energy and Communications Ministry of Defence *Operational:* - Swedish Maritime Administration - Coast Guard - Police - Armed forces	*Policy:* - Ministry of Enterprise, Energy and Communications *Operational:* - Swedish Maritime Administration - Coast Guard	*Policy:* - Ministry of Enterprise, Energy and Communications - Ministry of Defence *Operational:* - Coast Guard - Swedish Maritime Administration	*Policy:* - Ministry of Enterprise, Energy and Communications - Ministry of Defence *Operational:* - Swedish Maritime Administration - Coast Guard	*Policy:* - Ministry of Justice *Operational:* - Coast Guard- Police

Table 14: Swedish MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
ESTONIA	Estonian Tax and Customs Board	Border Guard	-Ministry of Interior -Border Guard	-Ministry of Environment -Ministry of Agriculture	Maritime Administration	Maritime Administration	Maritime Administration	-Governmental crisis commission -Ministry of Interior	Maritime Rescue and Coordination Centre	Police

Table 15: Estonian MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
LATVIA	Ministry of Finance/ Customs	Ministry of Interior/ State Border Guard	-Ministry of Environment/Marine and Inland Waters Administration -Ministry of Defence/ Coast Guard -Port Authorities	-Ministry of Agriculture/National Board of Fisheries -Marine and Inland Waters Administration	-Ministry of Transport/Maritime Administration	-Ministry of Transport/Maritime Administration	-Ministry of Transport -Harbour Master Offices	-Ministry of Defence/Coast Guard -Ministry of Transport -Ministry of Environment	Ministry of Defence/ Coast Guard	-Security Police -State Police -Municipal Police

Table 16: Latvian MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
LITHUANIA	-Ministry of Finance -Customs Department	-Ministry of the Interior -State Border Guard Service -Naval Force (Ministry of National Defence)	-Ministry of Transport and Communications -Ministry of Environment -Lithuanian Maritime Safety Administration -Klaipeda Regional Environmental Protection Department	-Ministry of Agriculture -Fisheries Dept.	-Ministry of Transport and Communications -Lithuanian Maritime Safety Authority	-Ministry of Transport and Communications -Lithuanian Maritime Safety Authority -Klaipeda State Seaport Authority	-Ministry of Transport and Communications -Lithuanian Maritime Safety Administration	-Ministry of Transport and Communications -Lithuanian Maritime Safety Authority	-Ministry of Transport and Communications Maritime and Aviation Rescue Centres (composed by the Lithuanian Maritime Safety Administration and the Civil Aviation Administration	-Ministry of the Interior -Police Department

Table 17: Lithuanian MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
POLAND	-Ministry of Finance -Customs authorities	-Border Guard - Ministry of National Defense, - Ministry of Home Affairs and Administration	-Ministry of Infrastructure -Ministry of Environment -Maritime Offices - SAR	Regional Fisheries Inspectors	- Ministry of Infrastructure - Maritime Offices, - SAR.	-Ministry of Infrastructure, - SAR - Maritime Offices	Customs chambers - Border Guard	- SAR - Maritime Offices	- SAR	Border Guard, Ministry of Home Affairs and Administation, Ministry of Foreign Affairs (political participation in PSI)

Table 18: Polish MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
BULGARIA	Ministry of Finance/Customs Agency	-Ministry of Interior/Police -Ministry of Defence/ Navy	-Ministry of Transport/Bulgarian Maritime Administration	-National Agency of Fisheries and Aquacul Ture -Police	-Ministry of Transport/Bulgarian Maritime Administration	-Ministry of Transport/ Bulgarian Maritime Administration (for ships) -Port Administration (for ports)	-Ministry of Transport/Bulgarian Maritime Administration	-Ministry of Transport -Ministry of Interior -Ministry of Defence -Ministry of State Policy for Disasters and Accidents	-Ministry of Transport/ Bulgarian Maritime Administration	-Ministry of Interior/Police -Ministry of Defence

Table 19: Bulgarian MS key authorities

NETHERLANDS	OFFSHORE ACTIVITIES OF GOVERNMENTS (NETHERLANDS' PART OF CONTINENTAL SHELF)										
	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law enforcement	Other[4]
Policy ministry	Policy cooperation and integration through the Coordinating Minister for North Sea Affairs (= Minister of Transport etc.) and the Inter-ministerial Board of North Sea Directors. Integrated North Sea policy established in the General Policy Paper on Spatial Planning and underlying policy papers										
	Finance	Justice	Transport, Public Works and Water Management	Agriculture, Nature and Food Quality	Transport, Public Works and Water Management	Transport, Public Works and Water Management	Transport, Public Works and Water Management	Transport, Public Works and Water Management[5]	Transport, Public Works and Water Management	Justice	* Economic affairs[6] * Housing, Spatial Planning and Environment[7] * Foreign Affairs[8] * Defence[9]
Management	Management cooperation and integration through the North Sea Management Network, coordinated by the North Sea department of the ministry of Transport etc. Integrated management framework established in the Integrated North Sea Management Plan (2006-2015) and underlying operational programmes										
	Customs Administration	Public Prosecutor + Royal Military Constabulary	North Sea department	Fisheries Directorate + Fisheries Inspectorate[10]	North Sea department + Regional Authorities + Shipping Inspectorate[11]	Shipping Inspectorate + Port Authorities	North Sea department + Regional Authorities[12]	North Sea department	North Sea department	Public Prosecutor + enforcement services + National Police Service Agency	* State Supervision of Mines * Nature Directorate * Water Inspectorate
Operational	Operational cooperation and integration through the Netherlands Coastguard[13], under the operational coordination and command of the Royal Netherlands Navy. Integrated operational framework established in annual Coastguard plans and programmes										
	Coastguard	Coastguard	Coastguard	Coastguard	Coastguard + Regional Authorities + Shipping Inspectorate	Coastguard + Port Authorities + Shipping Inspectorate	Coastguard + Regional Authorities	Coastguard	Coastguard + Royal Netherlands Lifeboat Institution	Coastguard + National Police Service Agency	* Hydrographic surveys * Mapping and monitoring * Research

Table 20: Dutch MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
BELGIUM	-Customs and excise's services -Police	- Police - Customs and excise's services	*See attachment*	-Flemish Ministry for Agriculture - Defence Marine component - Police - Customs and excise's services	Federal Ministry for Mobility	- Federal Ministry for Mobility - Police - Customs and excise's services	*See attachment*	*See attachment*	*See attachment*	- Police - Customs and excise's services

Table 21: Belgian MS key authorities

Member-States	Customs	Border control	Pollution response	Fisheries control	Maritime safety	Maritime security	Vessel traffic management	Accident and disaster response	Search and rescue	Law Enforcement
IRELAND	**Policy** Revenue Commissioners; Dept of Justice, Equality and Law Reform. **Operational** Irish Police	**Policy** Dept of Defence; Dept of Justice, Equality and Law Reform. **Operational** Irish Defence Forces; Irish Police	**Policy** Dept of Transport Dept of Environment **Operational** Irish Coast Guard; Environmental Protection Agency	**Policy** Dept. of Communications, Marine & natural Resources **Operational** Sea Fisheries Protection Authority; Irish Defence Forces	**Policy** Dept. of Transport **Operational** Maritime Safety Directorate; Irish Coast Guard	**Policy** Dept. of Transport; Department of Defence **Operational** National Port authorities; Irish Defence Forces	**Policy** Dept. Transport **Operational** National Port authorities; Irish Coast Guard	**Policy** Dept of Transport; **Operational** Irish Coast Guard; Irish Defence Forces	**Policy** Dept. of Transport; **Operational** Irish Coast Guard; Irish Defence Forces; voluntary SAR services	**Policy** Dept of Justice, Equality and Law Reform; Dept of Defence **Operational** Irish Police; Irish Defence Forces

Table 22: Irish MS key authorities

As expected, the authorities acting around Maritime Surveillance are numerous. And, due to many historical and political reasons, and for practical reasons too, the organisations vary from country to country. Naturally, the countries with large sea areas, especially islands like Ireland and the UK, Malta and Cyprus, or the Mediterranean countries, all have invested lot in MS – both administrative and operational capabilities. Investments are obviously depending on the countries overall capabilities, but it is it goes without saying, that for some countries MS is more pivotal than for others. These countries are important to recognise, since they are perhaps more prone to invest in MS capabilities in the future too, thus potential customers.

Further, knowing the different authorities, and the multitude of them, is crucial beneficial to whoever is planning to do any selling initiatives. The key arguments might be tuned into either emphasising joint capabilities and sharing costs, where there are a multitude of actors, or convincing a single bigger authority to become the owner of RANGER solutions. In any case, this too is important when constructing the market analysis.

2.3.2 Companies and other organisations providing MS services and technology

In the tables below there are identified various organisations in the MS domain and its service and technology providing.

RADAR technology and other relevant data providers identified as competitors for the RANGER technology are presented in the final chapters, and it must be acknowledged that all of them can be potential buyers of RANGER solution, too. However, in this table below are presented entities and organisations that were identified either as competitors, paying customers and/or final RANGER service providers for the end-users based on their size or market position. First are presented the EU related organisations, then European private or state-owned companies that might have an interest on RANGER based on their mission or existing service portfolio. A column for a geographical area is added too.

Organisation	Type	Mission and services	Areas/regions
The European Border and Coast Guard	Public authority in Border Control, especial interest in the Mediterranean because of the immigration crisis	Promotion, coordination and development of European border management in line with the EU fundamental rights	All

Agency Frontex		charter and the concept of Integrated Border Management.	
The European Maritime Safety Agency EMSA	Public organisation, major source of support to the European Commission and the Member States in the field of maritime safety, security and prevention of pollution from ships.	The integrated maritime services, based on advanced maritime data processing, combining information from all the agency's maritime applications as well as other external sources. Services are offered directly to EU Member States and organisations. Users have full operational support, 24 hours a day, 7 days a week, through EMSA's Maritime Support Services (MSS). Also, capacity building.	All
The European Fisheries Control Agency (EFCA)	Public, European Union body for fisheries control.	The European Fisheries Control Agency (EFCA) is a European Union body established in 2005 to organise operational coordination of fisheries control and inspection activities by the Member States and to assist them to cooperate so as to comply with the rules of the Common EU Fisheries Policy in order to ensure its effective and uniform application.	All, especially Atlantic and the Mediterranean
European Union Naval Force ATALANTA (EU NAVFOR)	Part of the EU's integrated approach to Somalia, the EU NAVFOR was set up in 2008 within the framework of the European Common Security and Defence Policy and in accordance with relevant UN Security Council Resolutions and International Law.	To prevent piracy and related problems, reduce harm, secure commerce.	Southern Red Sea, the Gulf of Aden and a large part of the Indian Ocean, including the Seychelles, Mauritius and Comoros.
The Maritime Analysis and Operation Centre – Narcotics (MAOC (N))	(MAOC (N)) is an inter-governmental working group or taskforce comprising seven EU Member States: Spain, France, Ireland, Italy, the Netherlands, Portugal and the UK.	MAOC-N's mission is to tackle maritime drug smuggling in Europe, especially high seas (no pun intended).	Atlantic Ocean, Mediterranean Sea
Airbus (EU)	Private company, main business in aviation but also other business sectors	Beside aviation related businesses, extensive and accurate space surveillance solutions, including optical and radar satellite imagery for decision making.	all
CLS (Collecte Localisation Satellites, France)	Private company, owned by the French state.	CLS works in 5 strategic areas of activity, of which sustainable management of fisheries and maritime security, and fleet monitoring being the most relevant to RANGER. CLS process environmental data and positions, ocean and inland waters observations, and monitor sea activities.	All, mostly relevant to France

e-GEOS (Italy)	Private company, owned by ASI (20%) and Telespazio (80%) companies.	Operates a radar hub infrastructure where data from most of the available commercial radar satellites are processed and analysed on an H24 basis. In addition, e-GEOS is the worldwide exclusive distributor of COSMO-SkyMed constellation data anywhere in the world. Maritime applications include ship detection and tracking, near-real time tracking, strategic surveillance, oil spill detection and monitoring, and sea ice monitoring.	Mediterranean Sea, Atlantic Ocean, all
INDRA (Spain)	Private company	Indra follows a value creation strategy, offering customers comprehensive management solutions, from consultancy, to project development, integration and implementation, to IT outsourcing and BPO. It has proprietary solutions for various market segments: Transport & Traffic, Energy and Industry, Public Sector and Healthcare, Financial Services, Security and Defence, and Telecom & Media. Seeking to tackle Spain's current problems with drug trafficking and save the lives of illegal immigrants at sea, Indra developed comprehensive land and maritime surveillance systems that now protect more than 5,000 km of border of several European and Asian countries.	Mediterranean Sea and Atlantic Ocean, Gulf of Persia, all
Leonardo Selex Galileo (Italy)	Private company, Selex Galileo Inc. is part of the Leonardo company.	A global player in the high-tech sectors and a major operator worldwide in the Aerospace, Defence and Security sectors. Leonardo designs and creates products, systems, services and integrated solutions both for the defence sector and for public and private customers of the civil sector including the maritime and naval sector.	All
Thales (France)	Private company, owned partly by the French State (ca. 1/4), and Dassault Aviation (ca. 1/4), rest free float.	Aim is to help customers to make the right decisions at the right time and act accordingly in challenging environments. To help create a safer world, serving five keys sectors: aerospace, space, ground transportation, digital identity and security, and defence and security	All

Table 23: Selected stakeholders in MS data/information ecosystem

Following the national MS authorities presented in the chapter above, here above were presented selected stakeholders in maritime security and MS data/information providers. Common to all is that the players are big and international, if not global. Either they are entities that have a clear outspoken mission or legal obligation in maritime security, or then organisations and/or companies that could possibly relatively easily take the full ownership of the RANGER solutions, and amalgamate them into their existing portfolio and/or operations.

For example, EU NAVFOR operates in the Somalian coastal area and high seas and tries to prevent piracy. For the activities RANGER could be highly beneficial, since there are no existing radar infrastructure available. Instead of constant patrolling, the resources could be allocated to the most pivotal missions. More critical is that the EU NAVFOR has a clear mission in maritime surveillance, and thus need for good operational picture, that RANGER could provide. Further, with the mandate, the EU countries committed themselves to material and other aid. Thus, in theory if not in practice, there could be an opening for solutions such as RANGER.

Another example is Airbus or Indra. Indra is one of the leading global technology and consulting companies, providing various solutions in specific market segments, including transport and defence markets. Maritime surveillance is not INDRA's main business. Nor is it Airbus'. Airbus in huge in aviation. Nevertheless, both INDRA and Airbus are companies that could in principle be interested in the RANGER solutions: RANGER could fit well in their assortment of technologies. That is why, they are presented in this table and in this deliverable.

Understanding the potential use of RANGER, and revealing the market from this side, enables to proceed this far in the analysis. However, a deeper understanding of the RANGER solutions is needed to follow the logic of this analysis toward the business models and ecosystem analysis. Thus, following this brief presentation of the geographical market as well as the potential authorities and others as customers, the work will present next the RANGER solutions itself.

3 RANGER Solution and Components to the Market

3.1 Overall

So, what is RANGER and what are the different components that it can offer to the market?

In short, in RANGER there are the first, the **OTH radar**, which is a High Frequency Surface Wave Radar (HFSWR) system that has the ability to detect targets at very large ranges, beyond the radar horizon. (See sub-chapter 3.2).

Secondly, there is the photonically enhanced **PE-MIMO** radar, i.e. an innovative radar that complements the OTH radar in detecting targets in close range over several kilometres with high resolution. (See sub-chapter 3.3).

Beyond the two radars, RANGER is much more.

The RANGER platform has its back-end and front-end, as well as the gateways. The **Early Warning Engine** is the back-end system of the RANGER platform that interfaces with the **Uniform Communication Gateway**, the **Data Fusion** module and **Machine Learning** module, as well as with the **Common Information Sharing Environment (CISE) Gateway** and the **Advanced User Interface**.

The Early Warning Engine is responsible for early detection of events, data storage and provision of warnings and alerts. It is the core element which is closely interdependent with the Data Fusion and Machine Learning modules of the RANGER platform.

The Data Fusion module's main role is to take all the available measurements at a particular time step (t), that could be detections from different sensors (radars, existing legacy systems[5], and AIS[6] data), and fuse them in order to obtain a set of tracks (routes), which are related to the existing targets in the current maritime scene. It performs data association, hybrid tracking and caching.

The Machine Learning module will take input measurements from available sensors through the Data Fusion module, and employ machine learning methods to derive conclusions about the characteristics of the detected/tracked vessels and their behaviour. It performs clustering, classification and statistics analysis.

RANGER has two gateways. First is the Uniform Communication Gateway, which is the connecting link between RANGER project's radars, legacy systems and AIS with the Early Warning Engine and the Advanced User Interface (AUI). This gateway organises all incoming tracks into a single message queue and translates the data and metadata into a unified format (IVEF), so that it is forwarded in real-time to the Early Warning Engine and Advanced User Interface using a common model. The second gateway is the CISE translation gateway. It is a component that allows the integration of the RANGER platform with the CISE network. The CISE Gateway provides the OTH tracks, PE-MIMO tracks, fused tracks and alerts.

The front-end of the RANGER system, i.e. the Advanced User Interface displays the tracks from multiple data sources (i.e. OTH, PE-MIMO, AIS, and other legacy systems) as well as fused tracks. The Advanced User Interface also visualise the alerts of the Early Warning Engine in real time. The Advanced User Interface also allows the possibility at an operation to see RANGER information/data and early warnings/alerts on selected tracks.

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[5] In the RANGER context, legacy system refers to existing radars or such, that provide information to RANGER, but on which RANGER cannot have an influence. Thus the term does not imply that they are is outdated.

[6] The Automatic Identification System (AIS) is an automatic tracking system that uses transponders on ships and is used by Vessel Traffic Services (VTS).

RANGER foresees three exploitable outputs. Firstly, the RANGER OTH Radar solution, secondly the RANGER PE-MIMO Radar solution and last the integrated RANGER platform that combines the novel radar solutions with intelligent data processing for automatic target recognition. (RANGER GA 2017).

RANGER offering is going to be multidimensional, in the sense that not only the unified RANGER platform will be delivered to the maritime surveillance market but several product offshoots originating from individual sub-systems developments as well. (RANGER GA 2017)

3.2 OTH

The OTH radar is a High Frequency Surface Wave Radar (HFSWR) system that has the ability to detect targets at very large ranges, beyond the radar horizon. The functional modules of the OTH radar system are illustrated in the figure below.

The OTH radar is interfacing with the Early Warning System (EWS), of the RANGER platform.

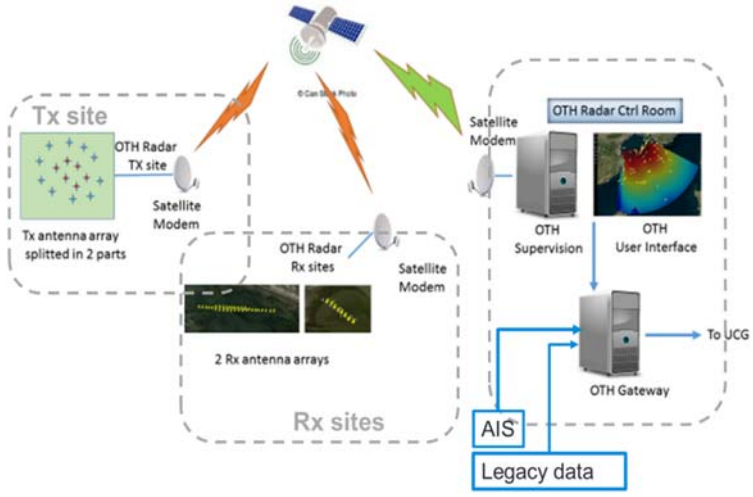

Figure 2: Schematic representation of the OTH Radar configuration

3.3 MIMO

Currently, there are three basic radar types on the market when classified by their scanning method. These are mechanical, phased array and multiple-input multiple-output (MIMO) radars.

The classical coastal or maritime radar is well known for its rotating antenna. The scanning of the field of view (FOV) is done completely mechanical. The instantaneous angle of antenna determines the angle, which is currently displayed on the radar screen and the range is measured by the round-trip time of flight of the emitted radio signal. A typical update rate for one complete rotation is 2.4s. Consequently, these types of radars suffer from a low update rate. Moreover, they are prone to wear and tear of the mechanical components. Also, the possibilities of post-processing the received signals from different angles is limited, since there is only one angle scanned at a time.

Contrary to the mechanical version, a phased array radar system uses multiple antennas and moves the scanning of the FOV from the mechanical to the electronic domain. Still, the FOV gets scanned with a focused beam, but the direction of the beam is focused completely by electronics. This is accomplished by electronic phase shifters to adjust the signal for each antenna element. This type

of radar has no moving elements and does not suffer from wear and tear. Furthermore, scanning is much faster, but still the beam is focused at one spatial point at a time.

MIMO radars are a further development, where each antenna element can send and receive independent signals simultaneously. This means that the complete FOV is illuminated at once, which allows to obtain a complete radar image in a single measurement cycle. As a result, the scanning time for the complete radar image can be in the order of a few milliseconds, allowing the use of averaging techniques to suppress noise while still outperforming conventional approaches in terms of refresh rate.

The signals from each transmit antenna are received by each receive antenna. The transmit signals are designed such that at the receiver, it can always be distinguished between the originating transmit antennas. Considering Mtx transmit antennas and Mrx receive antennas, a maximum of Mtx*Mrx independent reflected paths from a single object can be measured, as shown in **Error! Reference source not found.**.

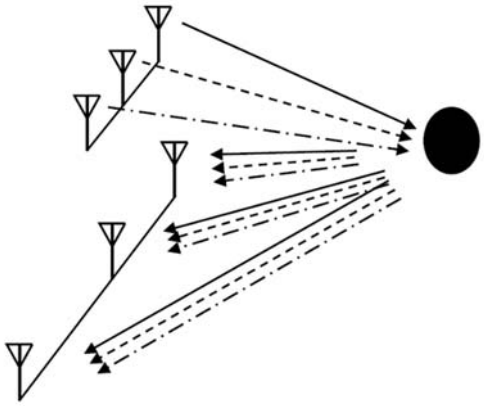

Figure 3: MIMO radar with 6 antennas, illuminating one object

In the example, the MIMO radar has 6 antenna elements, but receives 9 independent signals. The amount of received information about the radar target is equal to that of a phased array radar with 9 elements. MIMO radars can also use adaptive signal processing, allowing to concentrate the focus either on certain sections of the FOV or on a single radar target of interest or even a group of targets while at the same time suppressing clutter.

Considering the range coverage and dynamic range: keeping as a reference term the Signal to Noise Ratio or each couple of one Tx (isotropic) and one Rx antenna element and given the same total power emitted, the SNR of MIMO system as a coherent radar network scales up as NTx (due to the averaging over multiple Tx element) x NRx, while SNR of phased array scales up with NRx x NTx (due to Tx antenna focusing directivity) x NTx (due to total power). In other words, in the phased array the focusing of the TX beam improves the SNR and the range of the phased array and does not allow the instantaneous illumination of the area compared to the MIMO (ubiquituous radar). In a target tracking mission, there is no advantage to use a MIMO with respect to the phased array, while MIMO can be convenient in the mission of surveillance of all the space.

In the case of surveillance of all the space, the MIMO provides a continuous illumination of the target and cover all the bearings and a smaller area in range (due to limited SNR), with a response time limited only by the processing time; the phased array provides energy on target only with a duty cycle that is determined by the beam width size in Tx (that is inversely proportional to NTx) and consequently in unit time covers a smaller area in bearing, but a larger area in range (due to larger SNR), phased array response is limited by the electronic scanning time of all the area (usually less than 1second) and processing time. In the same electronic scanning time the MIMO can improve the SNR and consequently the range by time averaging. Practically this longer processing time is not a limit in practical sureveillance mission.

MIMO has the undoubted advantage of gathering information from the target coming from signal diversity (frequency, polarisation, angular view of the target in the case of distributed MIMO networks) that cannot be provided by phased array. This is at the expenses of a complex receiver in MIMO able to distinguish among frequencies, polarisation, including an array of receiving antennas and matched filter, one for each Tx antenna.

The MIMO radar designed within RANGER is specified to have 20 transmitters and 20 receivers, which is equal to a phased array radar with 400 antenna elements. Because of the large number of transmitters and receivers, the antenna array dimensions are in the order of several tens of meters. For a high quality signal distribution, a fibre-optic distribution network is therefore implemented. This network is immune against interference and can deliver high-frequency clock signals to all antenna elements without a loss of quality.

Furthermore, a central optoelectronic oscillator (OEO) enhances the radar system. The OEO is a high quality ultra-low phase noise signal source. Due to its low phase noise, targets in the radar image will be more sharp and focused. The photonically-enhanced MIMO radar (PE-MIMO) is designed to outperform state-of-the-art radar systems with the ability to provide a sea and land clutter cancelllation and definitively detect very small targets in the presence of large targets and interferers.

3.5 RANGER's competitive edge compared with other RADAR providers

RANGER solution offers vessel detection, recognition and identification capacities far beyond existing radar in terms of both targets size and distance, ranging over-the-horizon.

The RANGER architecture will be designed to be both scalable and modular in terms of its components and outputs. Further, the RANGER platform will be developed in a way to achieve sustainable integration with the CISE framework of services and EUROSUR framework, while being also available as stand-alone version. The RANGER Advanced User Interface is a component specifically designed to provide multiple categories of users (e.g. radar designers, operational users, and result stream subscribers) without requiring extensive training.

The substantial advantages provided by the two ground-breaking Radar technologies developed in RANGER are the enormous detection range that extends over the horizon and the unprecedented high resolution that allows for the accurate detection of small, fast manoeuvring vessels. RANGER will leverage the combination of these two complementary to each other technologies, to take a step further towards the design, implementation and provision of a system that not only detects targets, but has the ability to identify and track vessels within the range limits of its sensors detection capability. Thus, RANGER will develop a platform that supports maritime surveillance operators and consequently maritime security operations, by providing early warnings, alerts and recommendations to its users.

4 Premises for the Business Modelling

4.1 End-users may want integrated RANGER or only certain components

In the previous chapter was described the various components of RANGER, namely OTH and MIMO radars and the Early Warning Engine (EWE). EWS is in turn composed of Data Fusion Mechanism and Machine Learning Module. It is presumable that there are end-users who are willing to have the integrated RANGER solution, whereas some end-users may need only certain components of it. The starting point for the business modelling is therefore this kind of variety. Furthermore, the end-user may be interested in the RANGER solution and/or component as part of the CISE environment, or as stand-alone service.

4.2 Who is capable and interested to invest in the technical (radar) platform?

One high-level objective of RANGER project is to lower total cost of ownership (acquisition, installation, operation and maintenance) compared to existing radar solutions. (RANGER GA 2017). In addition to this efficiency approach, we can also seek higher capacity utilization of RANGER investments through service –and sharing economy approach, and thus lower the total cost of radar-based MS.

Key question is that are maritime surveillance municipalities and other actors interested or even capable buying expensive Radar technology – or taxpayers willing to finance big investments. Alternatively, are those MS professionals and taxpayers (citizens) just in need of enhanced MS capability in a reliable and sustainable way? Furthermore, what is the most effective way of utilizing the investments needed in Radars in various markets?

The implementation and use of the RANGER solution including radar(s) requires investments that can still be high for single end-user organisations. Selling own radar to each end-user ca be a good business for technology providers – but only if there are end-users willing to pay the investments and the running costs of the solution.

In case there are more than one potential customer in the same area interested in RANGER, business models based on sharing economy may be attractive and reasonable from the viewpoint of moderate pricing and effective use of resources. This solution means that the paying customers (the countries) utilizes the same resources for their own purposes.

If there are many end-user organisations in the same radar coverage area especially integrated in Border Control, the potential investor for the technology (and the customer for the technology provider) could be a joint EU organisation, like Frontex. This organisation then provides RANGER as a service for the end-users. In this case, the use of RANGER for border control could be free of charge, whereas the use for other purposes could be a paid service.

The latter is definitely a plausible option e.g. in many Mediterranean areas where both Greece, Italy, France and Spain operates various MS activities (border control, customs, SAR, environment, fisheries) on the common radar coverage area.

Finally, what is needed is to figure out the alternative costs of continuing in the present way instead of taking RANGER into use.

4.3 Will the end-users want to buy technology or services?

Does the end-user/customer of RANGER want to buy over the horizon radar technology, mimo radar technology and/or early warning software? Alternatively, does the customer just need enhanced capability for the maritime surveillance over the horizon and in archipelago areas, as well as capability to be proactive to potential anomalies as early as possible and in a reliable way?

Within industry, markets services have typically been seen only as an add-on to the core product offering. (See e.g. Kowalkowski, 2008). Before the millennium, the situation was same even in the marketing literature. Currently, both academics and practitioners emphasize the importance for product firms of implementing service-led growth strategies. Manufacturing industries and

companies in a mature stage have turned to the provision of industrial services and solutions (like industrial product/service systems IPS).

The emergence of software as a service (SaaS) has changed how software can be delivered, used, and managed. It is a new software delivery and pricing model, in which the vendor hosts, maintains, and manages the application from a central location; serves clients through a network; and charges them based on use. Gartner (2017) forecasts that the SaaS market will increase 20.1% in 2017 to total $46.3 and reach $75.7 billion by 2020. (Zhiling Guo and Dan Ma 2018) Furthermore, in the Information & Communication Technologies community, "Every-thing-as-a-Service" is emerging. Everything can refer to software, platform, infrastructure, communication, data, etc. Exposing things as services has different advantages such as abstracting the complexity of the digital and physical worlds, complying with the separation-of-concerns principle and shifting the burden of managing things internally to external bodies (e.g., cloud providers) in return of a fee. (Thar Baker 2018)

Since the turn of the millennium, the way how we see the economy and the purpose of the companies and their roles has changed too. American marketing scholars, Vargo and Lusch, published their first academic paper on goods dominant logic and service dominant logic in 2004. In the Service Dominant Logic, service, is defined as the application of resources linked to competencies (knowledge and skills) for the benefit of the customer. This is the basis of economic exchange. Resources do not possess value *per se*. Instead, value is derived from an outcome of a process in which customers integrate and use available resources, including their own knowledge, skills and motivations. Thus, service providers need to design resource constellations and service systems that support customers and include their resources in value co-creation. (Lush et al 2010; Vargo et al 2008).

The above service approach and service-dominant logic can also be linked to the concept of Performance Based Logistics (PBL) used e.g. in military supply and aerospace domain, or to the concept of Power by the Hour (PBH) used in private sector (for example Rolls-Royce has used the concept more than 50 years). The idea of PBL is to pay only for performance that has been rendered. (Glas & al. 2011; Knowledge@Wharton (2007).[7]

Regardless on our offering (integrated RANGER solution, or only some components of if) the difference in service logic compared to the goods logic is easy to grasp. RANGER is a service that can be tailored to the customer's needs (e.g. interfaces to specific legacy systems and other information sources). Orientation is on the ecosystem instead of market (see subsection xx). Furthermore, it is essential to understand that the price of our solution depends entirely on how much the use of RANGER creates value to its users. Therefore, continuous co-development with end-users and stakeholders is essential to build into RANGER business model, as well as to and build a dynamic and adaptive entity with Ranger's built-in capabilities for future development, including e.g. requirements of the EU Data Protection.

On the other hand, some customers may be interested in buying technology with supplementary services needed, including project implementation, maintenance and training.

[7] Please note that service –approach is also supported by EUROSUR regulation. According the principle of service orientation and of standardization the different EUROSUR capabilities shall be implemented using a service-oriented approach. Furthermore, the EUROSUR framework should be based on internationally agreed standard. (EC 2013, EUROSUR 2015).

4.4 Data protection regulation should not be a burden for end-users

EU data protection reform coming into effect in May 2018 set various requirements for the processing of personal data, as well as for the governance model of that data processing. The former issue (including privacy by design –approach) has been taken into account in the features of RANGER solution. The latter instead is more related to the final business model of RANGER solution. In the current version of RANGER, the AIS-data is the only data, which is included in the data protection legislation. However in the near future they may me new data sources or more accurate data sources (enhanced radar technology) which may include personal data.

The end-user of the RANGER solution can be either a municipality/officer or a private organisation. This has an effect on the legal framework to be applied, as well on the suitable business model.

Data controller is the organisation for whom the personal data is processed. Data processor is the organisation (s) who take the responsibility of the actual processing. Each data controller is responsible to nominate data protection officer, in case the controller is a public authority, in case it carries out large scale systematic monitoring of individuals (for example, online behaviour tracking); or in case it carries out large scale processing of special categories of data or data relating to criminal convictions and offences (GDPR, DPD articles xx-xx).

Maritime surveillance end-users are typically municipalities, public authorities. In case each end-user organisation is using RANGER solution independently, it means that they all have to nominate the Data Protection Officer. However, if they concentrate the providing of common RANGER services, only one Data Protection Officer is needed.

Data protection is a critical issue especially when the talking about stand-alone RANGER processing personal data.

4.5 How may RANGER be used outside MS in civilian applications?

RANGER solution or at least its various components have a big potential also for other businesses than MS. In the table below, there are identified potential services, which could utilize the same RANGER infrastructure on as the RANGER MS services in the area. By that way, we could maximize the use of RANGER infrastructure.

RANGER component	**Areas**	**service**	**potential customers**
OTH radar	Canary Islands	Tracking the sailing boats taking part in the ARC sailing competition	Organizer of the ARC (even from the viewpoint of SAR) Ordinary people interested on ARC sailing competition
OTH radar	Gotland area	Tracking the sailing boats taking part in the Gotland Runt –competition.	Organizer of the competition (Sandhamns Segling Sällskap?) Ordinary people interested on the competition.
OTH and MIMO	Channel Islands (e.g. Isle of Wight)	Annual offshore speedboat competition, thus tracking the competitors.	Organisers of the competition. Spectators onsite and online.
OHT and MIMO	East Mediterranean	Real time online schedule of ferries taking tourists from and to the Greek Islands.	Tourists, agencies, hotels, villa rentals, car rental companies, even airlines.
OHT and MIMO	All	Online platform to follow global maritime traffic. Cf. www.flightradar24.com	Potential "Trainspotters" of maritime environment. Vessel enthusiastic might want to know

			who and where various vessels are sailing. Also authorities
OHT and MIMO	All	Online platform of maritime accidents. Cf. www.tilannehuone.fi	For example, journalists, especially tabloid.
OTH and MIMO	Arctic Ocean	supporting air surveillance (air bridge on the arctic ocean)	

Table 24: Potential civilian use of RANGER outside MS

5 RANGER business model(s)

5.1 How to promote ecosystem approach?

5.1.1 The ecosystem approach

"We consider a business ecosystem to be a dynamic structure which consists of an interconnected population of organisations. These organisations can be small firms, large corporations, universities, research centres, public sector organisations, and other parties which influence the system." (Peltoniemi&Vuori, 2xxx)

According to RANGER GA the key achievement in view of RANGER' exploitation, will be to set the reference of relevant systems in Europe and to be able to create links and engage further industries to build on top of the proposed system (e.g. further sensor manufacturers, other CISE services, etc.). (RANGER GA 2017). This statement reflects the idea of open ecosystems.

The ecosystem analogy has been widely used for describing different kinds of structures and processes. In such an ecosystem, there are several vendors, large and small, providing software, hardware and solutions at every layer of the market, from the physical power infrastructure layer to the communications layer, up to the applications and services layer. New technologies are being developed and deployed, as well as competing and complimentary standards are being defined. Various systems and components support and take advantage of each other, resulting in benefits greater than those of the individual systems. See table below on telecom ecosystems (Deloitte 2016).

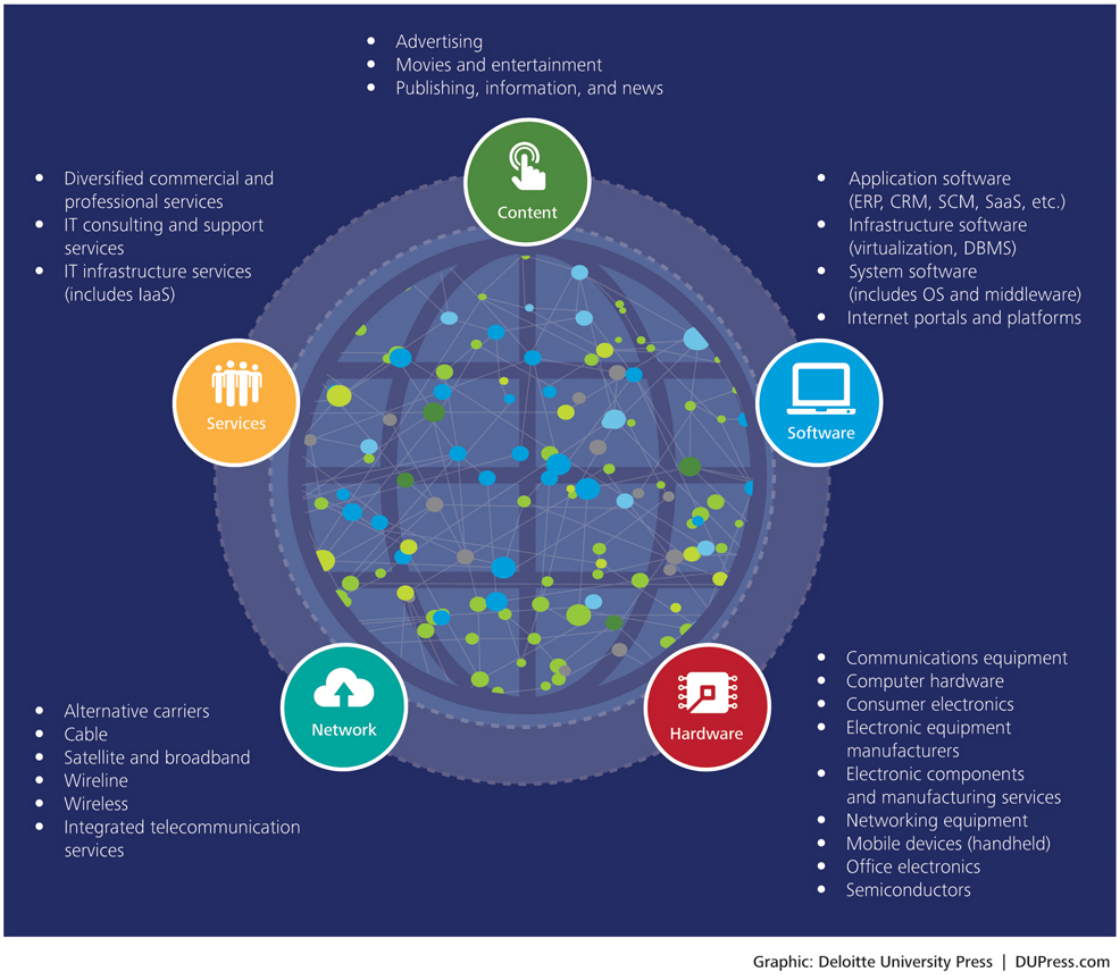

Figure 4: The Digital Ecosystem

This ecosystem approach has strong impact on RANGER's business modelling. From the viewpoint of Integrated Maritime Surveillance and Policy and of EU Common Information Sharing Environment (CISE) it is logical to approach ecosystem approach with open innovations instead on thinking RANGER businesses as single businesses with closed innovations.

Closed Innovation	Open Innovation
The smart people in our field work for us	Not *all* smart people work for us. We need to work with smart people inside *and* outside the company
To profit from R&D, we must discover it, develop it and ship it ourselves	External R&D can create significant value. Internal R&D is needed to claim some portion of that value
The company that gets innovation to market first will win	Building a better *business model* is more important than getting to market first
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal *and* external ideas, we will win.
We should control our IP, so that our competitors cannot profit from it.	We should profit from other's use of our IP (license out) and we should license in other's IP whenever it advances our business model.
We will own all results from contract research with universities	We will partner with universities to create knowledge and encourage use outside our field

Table: 25: Open vs. Closed Innovation (Chesterbourgh)

5.1.2 How to design a RANGER ecosystem of MS services

In the figure below there are sketched out RANGER solution from the viewpoint of different technology and service layers, as well as the business opportunities related. These layers can be converted as businesses in several ways from distributed model to centralized model (and something between them).

We can compare here the ecosystem in the telecommunication industry where the basic infrastructure with support stations is common for every operator, whereas the layers providing services for users. This kind of architecture enables lower investments from end-user/customer viewpoint and more efficient use of the capacity from the business viewpoint. Finally, this kind of technical platform enables also dynamic emergence of various service providers and thus "ecosystem".

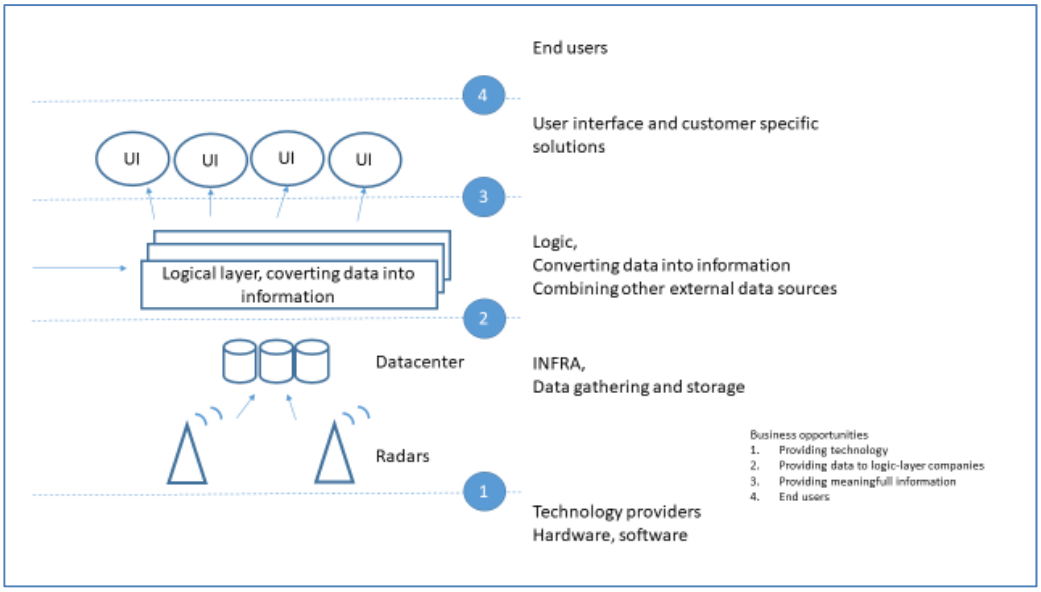

Figure 5: Business opportunities and layers of RANGER

The first layer is **the infrastructure layer**, which is also **the paying customer for the RANGER infrastructure technology providers** (radars and (at least) basic software for data gathering). The business model for RANGER partners could easily be a product-based model especially with the radars. Even licencing etc. can be applied. RANGER software providers could also sell their software as a service. The infrastructure provider can be already existing organisation (e.g. Frontex, Indra etc.) or even a new organisation established by RANGER consortium.

The second layer is the **logic layer** providing various data processing services converting data into meaningful contents. The layer utilize data coming from the first layer, as well as from other joint sources (e.g. AIS data) and customer-specific sources. The logical layer is **the paying customer for the infrastructure layer.** The providers of machine learning etc. in RANGER can also have this layer as their customer (in case the infra-layer does not include all the RANGER software).

The third layer is **the user interface layer** providing user specific services based on the data collected and processed in the earlier layers. This user interface layer is **the paying customer for the logic layer**.

The fourth layer is **the end-users' layer** needing the RANGER services in their MS and other activities. They are the paying customer **for the user interface layer**. They are buying MS services based early warning information.

The above description on the various layers and businesses can of course in the RANGER be more centralized, since there is not yet such a real ecosystem-approach in the area of MS. The infrastructure layer and the logic layer could e.g. be merged as a single layer, and even the user-interface layer could be connected in that same business. It must be noted that the more we merge various layers together, the more we may lose the flexibility and adaptability and innovativeness of the ecosystems.

5.2 Service led growth of RANGER

Businesses can pursue service led growth by adopting and managing co-existence of several system supplier roles simultaneously. First, companies as "availability providers" develop their service business based on their existing service capabilities, thus aiming for customer loyalty, business growth, and stable revenue streams. Second, companies as "performance providers" provide a platform for offering even more advanced solutions, which solve strategically custom-specific

challenges, similar to project-based sales. Third, by becoming "an industrializer" companies are standardizing previously customized solutions to reach larger customer base and scalability. Alongside with these different roles, companies have to balance expansion and standardization activities in order to make offerings more competitive and delivery process more efficient. This includes identifying elements which can be scaled up and to modularize them. In many cases, new services and solutions are developed *ad hoc*, and in close cooperation with customers (e.g. new customized offerings), rather than in a planned fashion. Potentially, elements of such offerings can later be standardized and formalized, making it possible to offer them also to other customers as well. (Gallouj & Weinstein, 1997; Kowalkowski et al., 2012).

These various models are open to RANGER too (See also RANGER GA about Top Line-Fostering value creation and Bottom Line Industrializing and reuse).

5.3 Traditional product approach with complementary services

Although above are presented somewhat newer and innovative business models, the traditional and perhaps more conventional product approach must not be ignored. This is especially true in cases when the market is indeed interested in traditional product approach, and thus services are not in the core of the offering. To put it simply, in these cases, the customer will buy product (technology) and hence make the investments in it. However, the complementary services are still needed in order to operate in the market. The main aspects of this business model will therefore be (see also RANGER GA):

- **Technology**. Revenues stemming from selling the RANGER integrated platform.
- **Project Implementation Services**. Deliver turn-key solutions to agencies across Europe.
- **Maintenance and Support Services** (for Software and hardware components). Recurring revenues coming from the support services to the procured components and/or solutions.
- **Training**. Training of personnel for using the platform and configuring the different components.

5.4 Potential business models in various regions

Business for RANGER technology providers	Paying customer	The investor	Final offering for the end-user	Optimal amount of potential end-users in various regions	Possible regions and customers
1 Each RANGER component as a product > RANGER consortium members start to sell their products independently including supporting services of training, maintenance etc.	a) End-user organisations/ countries	End-user organisations/ countries finance the investment by themselves.		Individual or only few countries in region in need of the product. (probably making the investment together)	
	b) Infrastructure organisation	Infrastructure organisation carries the investment risks.	Leasing radar technology?	Several or all the countries in region in need of the product.	
	c) Service organisation(s)	The service organisation or the RANGER technology provider carry the investments risk.	Radar as a service Early warning as a service	Several or all the countries in region in need of the product.	Mediterranean sea Frontex or EMSA as the paying customer for RANGER partners
2 RANGER solution as a product > Joint company is needed responsible for the customer interface and supporting services and maintenance & training.	same as above	same as above	same as above	same as above, but probably several or all the counties in the region in need of the solution	same as above
3 Single RANGER technology as a service > each technology provider start its own service business	a)end-user organisations/ countries b) Service organisations.	RANGER technology providers carry the investments risks related the technology needed in the service	Radar as a service Early warning as a service	The more there are countries interested in the service, the more attractive is this model for the RANGER technology providers	
4 RANGER solution as a service ***** Enhanced MS capability as a service = RANGER consortium start a new joint business as service provides selling RANGER service.	a) end-user organisations/ countries b) service organisations	The new RANGER solution provider carries the investments.	radar as an service early warning as a service	the more there are countries interested in the service in the area, the more attractive is this model also for the RANGER technology provider	Mediterranean sea End-users in various countries as paying customers or e.g. Frontex as a final service provider

Table 26: Potential business models in various regions

In this table above is presented the different potential business models, together with the geographical area. However, it must be noted that the business models are not restricted to these. This table is more to show the logic how business models can be drafted, and how depending on how RANGER is seen (component as a product, solution as a product, technology as a service, or solution as a service). Each way of looking at RANGER opens several options of business models and thus new markets. Similarly, if we change the region to for example, the Caribbean Sea, again new customers and end-users will emerge.

6 The Study for Priority Markets

In this chapter, we will provide PESTEL (political, economic, social, technical, environmental and legal) analysis of the chosen RANGER MS markets, namely Mediterranean Sea and Canary Islands in Atlantic.

6.1 The method

The analysis is done by utilizing the available PESTE –analyses on various countries, and then focusing them more in detail in the context of MS activities and RANGER. The latter process is based on the interview of MS experts. (See the list of references and interviews in the appendix)

Since the starting point for the PESTE are the countries in the markets, the categories in this analysis varies a little bit from those defined earlier as potential markets. (See the last column of the table below).

Area/region	EU countries	Other countries	Market areas/regions
Western Mediterranean	Spain, France	Morocco, Algeria, Tunis	M1
Central Mediterranean	Italy, Greece	Libya, Tunis	M2,M3,M4,M5
Eastern Mediterranean	Greece, Cyprus	Turkey, Egypt, Israel, Lebanon, Syria	M6
Canary Islands/Atlantic	Spain, Portugal	Western Sahara, Morocco	A1

Table 27: Areas and countries of interest from Market Analysis point-of-view

6.1 Market 1 West Mediterranean Sea

Probably not any surprise for the average reader of this deliverable, but France is located on the western edge of Europe, bordered by the North Atlantic Ocean in the west, by the English Channel in the northwest, and by the North Sea in the North. France has borders with Belgium and Luxembourg in the North-East, Germany, Switzerland and Italy in the East, the Mediterranean Sea, Monaco, Spain and Andorra in the south. In addition, France shares maritime borders with the United Kingdom.

The mainland France, covers an area of ca. 552000 km² (incl. Corsica). The population of France is ca. 67 million people, of which around 65 million lives in the European part of France (and Corsica). About ca. 2 million in its overseas regions (French Guiana, Guadeloupe, Martinique, Mayotte, and Reunion). Other major dependencies are French Polynesia and New Caledonia.

The largest city and capital is Paris. Spoken language is French, which is also the official language.

France is one of the most modern countries in the world and is a leader among European nations. The political system is so-called semi-presidential republic with a head of state with strong executive power (together with the ministers). To balance that, there is the separation of powers which consists two others: a legislative branch, and a judicial branch.

The French economy is highly developed, and there is free-market-orientated business model. Thus, during the last decades, the governments has partially or fully privatised many large companies.

The Kingdom of Spain, is together with Portugal, one of the two countries situated on the Iberian Peninsula. Spain has a coastline at the Atlantic Ocean in North and the Mediterranean Sea in South-East. Spain's neighbouring countries are small Andorra, and Gibraltar (U.K.), bigger EU-neighbours France and above mentioned Portugal, and Morocco in the South (at the Spanish

exclaves of Ceuta and Melilla on the North African coast). Spain has also maritime borders with Italy and Algeria.

Spain covers an area of ca. 505 000 km², and thus Spain is the fourth largest country in Europe. Spain has a population of ca. 46 million inhabitants. The largest cities are Madrid and Barcelona. For now, Spain is by 1978 constitution a unitary state, in which the central government is the ultimate supreme power and the country's administrative divisions exercise only powers that the central government chooses to delegate. The king is the official head of state and commander-in-chief of the armed forces. However, the highest legislative body in Spain is the two chambered Parliament, and the executive power is in the hand of the prime minister.

In general, both Spain and France are politically and economically stable countries, where not only the living standards are good, but the countries offer predictable and reliable ecosystem for business. For example, the rule of law is respected, governance is relatively good, and there is a low level of corruption.

Although, the political systems of both Spain and France are in a way fundamentally different, since one is a monarchy and the other is notorious for its republic (currently the so-called Fifth Republic) the two countries share a lot of common, mostly due to belonging to the European Union and hence sharing its values and norms.

Both Spain and France have somewhat stable economies, despite the economic crises of 2008 in Spain, and constant sentiment of crisis in France (e.g. les Gillet Jaunes). Nonetheless, on global scale the two countries are still in a position where investments can be made (both public, i.e. done by state, but also private ones, i.e. mergers and acquisitions).

From RANGER point-of-view the political will for RANGER type solutions are somewhat favourable. In favour of France is the fact that the OTH is already installed and in use. Is Spain, perhaps the need is more imminent: the migration flow is stronger from North Africa to mainland Spain, and also the narco-trafficking is more pertinent in the Spain (especially Galicia region in the north of Spain) where the biggest challenge is fast moving RIB-vessels.

From high politics point-of-view, it is noteworthy that France is the permanent member in the United Nation's Security Council. Thus, France is in a position to participate (or obligated, depending on the viewpoint) in decisions on global maritime surveillance. For example, recently in summer 2019, France took a decision to participate in maritime surveillance operations to combat evasion of sanctions by North Korea.[8] Hence, if there are similar type of high-politic decisions that lead into non-military maritime surveillance requirements, these occasions might open possibilities for RANGER solutions too.

Societally, there is no major restrictions in the use of RANGER, although both have substantial amount of tourism on their coastal areas. Nonetheless, the use of RANGER should not pose a problem, and in fact in France the OTH radar is already in use.

From RANGER's market point-of-view, these two countries are very important:

- OTH already in use in France.
- needs for the solutions.
- capabilities to purchase (both state agencies, but also EU-organisations and private sector).
- the preparedness for ecosystem approach thinking is strong.

[8] Ministry for Europe and Foreign Affairs of France (2019). Press release: France's participation in maritime surveillance operations to combat evasion of sanctions by North Korea (17 June 2019). Available online at https://www.diplomatie.gouv.fr/en/french-foreign-policy/security-disarmament-and-non-proliferation/news/news-about-disarmament-and-non-proliferation/article/france-s-participation-in-maritime-surveillance-operations-to-combat-evasion-of

6.2 Market 2 Central Mediterranean Sea (Italy)

Who would not know Italy and its unique boot-like shape situating in the middle of the Mediterranean Sea? Anyhow, much of Italy is the peninsula, and thus surrounded by the Mediterranean Sea: Adriatic Sea in East, the Sea of Sicily in South, the Ionian Sea in South-East, the Ligurian, and the Tyrrhenian Seas in West.

Italy's neighbouring countries are also numerous: Austria, France, Slovenia, and Switzerland (land borders) and Albania, Algeria, Croatia, Greece, Libya, Malta, Montenegro, Spain, and Tunisia (maritime borders).

Altogether, Italy covers ca. 301000 km^2. The two large Mediterranean islands belong to Italy, too (Sardinia and Sicily). Italy's population is over 60 million inhabitants, and the largest city is the capital Rome. Other major cities are Florence, Milan, Naples, and Venice. In Italy they speak Italian.

Italy is a democratic republic (the monarchy was replaced in 1946). Italy has a two-chamber parliament, Senato della Repubblica and the Camera dei Deputati. Elections take place every five years.

The country's main economic sectors are tourism, fashion, engineering, chemicals, motor vehicles and food. Italy is a member of the EU, like above presented France and Spain, as well as later presented Greece and Portugal. Italy is part of the G8 group (together with France) thus recognised strong industrialised country, in fact the world's seventh largest economy. However there is a strong division between the rich North and less developed South (especially high unemployment rate).

In general, Italy is at the forefront of European economic and political unification and strongly committed to NATO. Currently, populist parties have made the political running, and formed a coalition government in 2018.

Italy is hit with the current migration crisis (together with Greece) harder than any EU country. As a result, there is a very strong urge to solve the problem, and technology is often seen as one saviour. However, despite the will, there is not clear and coherent political view on the way the challenge could and/or should be solved, and thus there is a constant political argument about the right way to do things.

Nonetheless, on the somewhat lower levels of politics Italians are very much emphasising the importance of maritime surveillance, and taking lot of actions: one key is the commitment of Italians to the CISE framework. Also, Italians are very active in research projects in maritime surveillance.

From RANGER's market point-of-view, Italy too is very important:

- Italy is committed to European maritime surveillance organisations (including research and information sharing), e.g. NATO CMRE, CISE etc.
- Italy's needs for maritime surveillance are huge, not just the amount of sea border, but also the challenges of migration crisis, not forgetting smuggling illegal substances.
- Italy has strong high tech traditions, and many companies that could be possible buyers of the RANGER solutions.

6.3 Market 3 Eastern Mediterranean Sea (Greece)

Greece, (the official name is the Hellenic Republic) stretch over two (main) peninsulas and over thousands of islands in the Aegean Sea in the East, and in the Ionian Sea in the West. Greece's border countries are Albania, Bulgaria, Turkey, and the Republic of Macedonia (land borders), and Cyprus, Egypt, Italy, and Libya (sea borders).

Greece's area is ca. 132 000 km², and it has a population of around 12 million people. The largest city is the capital Athens. In Greece they speak Greek: "γεια!"

Greece has strong ties to Western security political community: it joined NATO already in 1952. and has been a member of European Union since 1981 (de jure member of the European Community, since the EC became EU only later with the Treaty of Maastricht and Treaty of Lisbon), thus committed to common European border control and to fulfil all oblications.

The economic crisis of 2009 is still affecting much of Greece. As a result, public investments collapsed in Greece under the fiscal crisis (Monastiriotis & Psycharis, 2014). After almost a decade of contraction and stagnation, Greece's economy started to grow again in 2017. (COM 2019). However, still after ten years, public investments is growing slowly which may create obstacles in possible investment in systems such as RANGER. This is due to the fact that political influences are a major determinant for the allocation of any public investment, and the politics are not necessarily in favour for those. (Monastiriotis & Psycharis, 2014).

On the other hand, the economic situation could be better if Greece would not be one of the EU countries that is taken much of the burden in the current migration crisis. The amount of irregular immigrants arriving to Greece is the highest of the European countries. Therefore, Greece has very strong need for finding solutions for maritime surveillance. Thus, public investement in this could be justifiable.

Another reasons perhaps for Greece are both the geo-strategic position of Aegean Sea and ith greography with thousands of island accessible by boats. These add to the challenges of surveilling borders. Also, tourism is very important and hundreds of thousands of tourist come annually to Greece to enjoy the sea and sun. Thus, the need for SAR operations to rescue leisure boats cannot be ignored. Fishermen can end up in troubles as well, and fishing is important in Greece: therefore controlling and surveilling that too is important.

Because of the tourism and rich history on what comes to finding place for the RANGER solutions might be a problem in Greece. However, carefully selecting the places for the antennas, deploying RANGER into Greece should not be a problem: we did it already twice during the demonstration pilots in Chania.

Greece from RANGER market point-of-view and important market:

- very high demand
- questionable financial resources
- commitment of authorities (for example HMOD is part of the RANGER consortium)
- Some societal constrains
- No big companies willing to buy solutions to their portfolio.

6.4 Market 4 Canary Islands and Azores in the Atlantic

This last country and/or area specific analysis concentrates on areas governed by the two countries of the Iberian Peninsula, Spain and Portugal, namely the Canary Islands and the Azores, both in the Atlantic Ocean.

The Canary Islands are composed of seven islands close to the South coast of Morocco. The territory has is ca. 7500 km2, and the amount of inhabitants is around 2,2 million.

The Azores archipelago is an autonomous region of Portugal located in the North Atlantic, some 1 500 km from Lisbon. The Azores contains of seven islands and several islets. The marine surface area of the Azores is almost 955 000 km2, thus one of the largest so-called Exclusive Economic Zones (EEZs) in the European Union.

From a business point-of-view, both the Canary Islands and the Azores (perhaps more the first than the latter) present a wide range of possibilities partly due to its strategic geographical location. From the location and size comes obviously the need for maritime surveillance too. Especially since both areas are known locations for drug smuggling operations, and Canary Islands are in addition a destination for irregular immigration. Furthermore, the islands lack of existing maritime surveillance capasity, so RANGER could be a market opener.

Viewpoints from market perspective:

- Need for MS: large and problematic area
- no existing solutions that needs to be replaced

7 Value Creation with RANGER

This Chapter concentrates on the value creation of RANGER in comparison with other existing solutions.

Taking into account the fact that RANGER is ground-breaking technology and has shown only briefly shown its potential, namely in the two pilots in France and two in Greece, we can make the comparison with very limited knowledge. Further, the full potential of other existing solutions is only on a very limited knowledge base on what comes to detailed information on either the actual performance or the cost structures. Therefore, this chapter concentrates more on the principles and practices of the different ways of conducting maritime surveillance and comparing the advantages and disadvantages of different solutions. It goes without saying that no single solution can replace all existing, nor can the authors of this deliverable make the choice on what would be best for an end-user's point of view. However, a comparison can be made to help to make the selection.

In the next sub-chapters, we present briefly the Maritime Surveillance solutions currently in use, for example, coastal radars, satellite surveillance, boat patrolling, aerial surveillance etc. Then, their best features are presented along with their weaknesses in ANNEX D. At the end, they will be compared with RANGER solutions and a table of the comparison is made to visualise the results.

7.1 Existing Maritime Surveillance Methods

The information and details of maritime surveillance systems presented in this chapter are based on public sources, mostly websites and commercial brochures. The founded information is analysed by the authors' best knowledge of surveillance systems technical solutions.

It must be underlined that RANGER is for non-military use. And that many maritime surveillance methods presented below have somewhat dual use: both for military purposes and for civilian, including border control and SAR-operations. Thus, the comparison of the different methods can be difficult – often impossible. Nevertheless, a sophisticated reader can make his or her judgement and use this material to get an overview for the value of RANGER.

7.1.2 Surveillance Radars

OTH Radars

BAE

The British BAE Systems High Frequency (HF) Over-The-Horizon Surface Wave Radar (HFSWR) is designed for both civil and military applications. By utilising the HF surface wave propagation effect, low level target detection and tracking capability are provided at extended ranges. For maritime situation awareness, HFSWR is particularly effective when integrated with other sensor and identification systems. (BAE Systems, 2019)

According to BAE HFSWR, the radar is capable of up to 120^{0} azimuth coverage over the long ranges. The modular design can be expanded to cover an entire national coastline, while its varied application can encompass civil maritime surveillance, Exclusive Economic Zone (EEZ) monitoring, low and high-level air defence and co-ordinating the civil assets. The exact numbers of detecting capabilities are not given but according the public sources Rib can be detected just behind the horizon and the detection range increase according to targets size. (BAE Systems, 2019)

Israel Aerospace Industries

The Israel Aerospace Industries Ltd. ELTA ELM-2270 0TH radar is long range High Frequency (HF) band coastal surveillance radar, designed to detect sea surface targets and low flying aircraft, far beyond the local horizon.

The radar monitors activity up to 200 NM from the seashore, by employing HF surface wave propagation. The system transmits a wide-angle beam, simultaneously covering 120° in azimuth,

while the receiving section comprises of one or more arrays of vertical antennas, which provide instantaneous coverage of the entire sector.

Employing phased array technology and unique interference cancellation techniques, the radar provides reliable, persistent coverage of the broad maritime area at all times, regardless of atmospheric conditions or sea state. The radar application ranges from Exclusive Economic Zone surveillance, coastal Over-The-Horizon Situation Awareness Picture (ASP) generation, and low altitude aircraft detection.

The detection capabilities are mentioned to be 370 km to a 1500 tons ship, which is approx. 230 Nm and 130 km (80Nm) to low flying aircraft (King Air 200). The 1500 tons ship is for example approx. 70 m long, 15m high cargo vessel and from that perspective a large target for radar detection. The King Air 200 is medium size aircraft 13,4m long 4,6m high, operated with two turboprop engines. The informed altitude is low, which means at least 150m above sea level. (FAA 2019)The airplanes speed is also much higher than a vessel, which means it is easier for radar to detect.

The blind spot is not mentioned (shortest detection distance).

The radars' maintenance is mentioned to be cost-effective without any specification for the costs, used man hrs or average time between maintenance. (IAI, 2019a)

Frequency band	Azimuth coverage	Detection range	Range accuracy	Range resolution	Azimuth resolution	Detection capabilities	
HF	120º	200 Nm	2 km	3 km	array size frequency dependent	1500 tons Ship	low flying aircraft (King Air 200)
						370 km	130 km

Table 28: ELM 2770 Specification

Raytheon

Raytheon Canada's third generations HFSWR (High Frequency Surface Wave Radar) is an over-the-horizon sensor that is designed to detect and track ship traffic within a nation's 200 nautical mile EEZ. The technology has been in development for more than 20 years with the strong support of the Canadian Department of National Defence (DRDC). Internationally, Raytheon Canada has operational systems in the Black Sea and the Indian Ocean areas, which are successor to third generation HFSWR. Raytheon's HFSWR is fully exportable design. (Raytheon 2018) The system has been tested and it has proven to be functional in all operating environments and a wide range of sea state conditions. In a presentation, the radar coverage is mentioned to be 280 km (173Nm) to a 20 m vessel president tracking. In the same presentation radar coverage from 20 to 200 Nm is mentioned to the class 1 vessel (Tugs, Commercial fishing vessel etc.) in sea state 3 in daylight 200km and during the night 120 km. (Raytheon, 2017). The Raytheon HFSWR antennas are also quite notable and disruptive to landscape.

Comment: Unfortunately, additional technical information was not found in reasonable time of studies. Noteworthy is that Raytheon's HFSWR is already in operative use which makes it interesting to potential customers.

China

According the media, China has developed a HF ground wave detection radar, which is said to have successfully detected stealth targets. China's famous radar expert, professor of Harbin Institute of Technology, and academician of the two academies Liu Yongtan won the 2018 National Supreme Science and Technology Award. The winning project is the domestic high-frequency ground wave detection radar. China has developed an advanced compact size maritime radar, which can maintain constant surveillance over an area of the size of India. (Global Security, 2019a)

Comment: the Chinese systems might not be competitor to RANGER's OTH radar while China unlikely is willing to deliver its technology worldwide. However, it gives the input that new innovative solutions are ongoing on OTH radar markets round the world.

About the OTH markets

On the OTH market there is only a few option in the category where RANGER's radar is located. For main products are BAE HFSWR, ELM 2270, DXT Stradivarius and Raytheon HFSWR. All the OTH radar presented in this chapter use same High Frequency Surface Wave principle to detect the maritime targets as the RANGER's use. Other technical differences between the systems was impossible to find due the limited information in public sources. For sure, each of them has their own advantages, which the customer has to valuate against their specific needs or requirements. All the radars mentioned in this chapter are in operative use as well as under the development process. Novel techniques will be used as they are found and in that perspective new version/generation is coming to the market.

As mentioned China has operative HF radars, the knowhow and resources to develop radars for this category. According the media China is developing OTH technologies and new products or might update the existing ones but quite limited information is available.

Short range radars

ELTA

The ELM-2226 ACSR (Advanced Coastal Surveillance Radar) is an innovative Coastal Surveillance Radar, optimized for the detection of all types of surface targets even under extremely adverse sea conditions. ELM-2226 is 3rd generation Coastal Surveillance Radar developed as solid state. It is mentioned to be user-friendly, cost-effective and compact systems which features are continuous, gap-free, automatic detection and tracking of targets providing a reliable situation display.

The system for coastal surveillance and VTS can be supplied either in fixed or mobile configurations. A cluster of radars could be operated from the same console. Optional capabilities are mono pulse for azimuth accuracy and Inverse Synthetic Aperture Radar (IASR) for target classification. As an application to the systems is mentioned (IAI, 2019b):

- Prevention of illegal immigration and drug smuggling
- Maritime traffic control
- Prevention of illegal fishing
- Prevention of terrorist activities
- Detection of submarine periscope and radar antenna
- Detection of airborne targets within the radar's main beam

The ELM-2226 belongs to same family as OTH radar ELM-2270 which makes the system an interesting challenger for RANGER.

Frequency band	Azimuth coverage	Beam width ↔/↕	Automatic detection/ tracking	Range accuracy/ resolution	Interoper a-bility	Detection capabilities (sea state 3)		
X	360º	1,5º/3, 5º	Over 500 targets	High	EO, CSM/DF, AIS	Rubber boat	Patrol craft	Large ship
						20 km	60 km	Horizon

Table 29: ELM2226 specification

Furuno

Furuno provides surveillance systems that are designed for coastal surveillance, port surveillance and ground surveillance. For example, their maritime solution FF-Coast is designed to be used for the surveillance of coastal, port and critical areas. The FF-Coast system produces a situational traffic picture, reliably and in real time, to increase safety and security in the above-mentioned areas. One advantage mentioned by Furuno is that several kinds of sensors can be connected to the FF-Coast system for surveillance purposes. The number of these sensor stations are not limited per workstation. Sensors, which can best be applied in each area, can be selected to establish a cost-efficient solution. (Furuno 2019).

Depending on the radar model and antenna type the radar system can track and control fast-moving small targets (6 meters or larger) at sea level at distances from 3 to 20 kilometres. In normal cases, the number of tracked targets are not a limited. The camera system can, depending on the chosen camera models, reach similar levels of efficiency. The alarm zone, type and generation management of abnormal behaviour, collision risk or other predetermined factor can be customized based on customer needs. (Furuno 2019).

The following benefits for FF-Coast system are mentioned (Furuno 2019):

- Consistent and reliable system in 24/7/365 operation, even in extreme conditions
- Small targets real time tracking
- Situational traffic picture generation and recording in real time
- Camera system integration and automatic target tracking
- OSD integration possibility (FOIL-200 oil radar)
- Flexible alarm zone generation and alarm management
- Cost efficient, easy to use and intuitive solution

Comment: Unfortunately the exact performance statistics were no available for Furuno.

Hensoldt

Hensoldt provides for coastal surveillance fully coherent radars capable of detecting low Radar Cross Section (RCS) targets such as small wooden boats and RHIBs. The SBS-700 (non-coherent), SBS-800 and SBS-900 (both fully coherent) radar systems have been designed to align with the 'Basic', 'Standard' and 'Advanced' capability types of IALA V-128 recommendation. SBS800/900 radar have been equipped with SharpEye™ providing the user the ability to detect targets at longer ranges, earlier and in heavy rain and high sea states. The SharpEye™ transceiver of the SBS-900 systems is designed to be situated outdoors, close to the antenna turning unit and not requiring an air-conditioned enclosure to be built close to the top of the mast. The system is remotely controlled over the Wide Area Network (WAN). Local control is also possible via the RDU control panel or optional service display which main purpose is to enable the maintainer to fully control and display the radar locally for commissioning and maintenance purposes. (Hensoldt, 2019)

<table>
<tr><th>Frequency band</th><th>Azimuth coverage</th><th>Beam width ↔/↕</th><th>Automatic detection/ tracking</th><th>Range accuracy/ resolution</th><th>Intero-perability</th><th colspan="3">Detection capabilities (sea state 3)</th></tr>
<tr><td rowspan="2">X/S</td><td rowspan="2">360º</td><td rowspan="2">X-band
↕ 14º
↔0,38º
S-band
↕14º
↔2,0º</td><td rowspan="2">Mount of targets is not mentioned</td><td rowspan="2"></td><td rowspan="2">Mentioned to be easily integrated with both new and existing surveillance and safety systems.</td><td>Rubber boat</td><td>Patrol craft</td><td>Large ship</td></tr>
<tr><td colspan="3">Max. instrumented range is mentioned, 48 NM</td></tr>
</table>

Table: 30 Hensoldt SBS 900 specification

GEM Elettronica

GEM Elettronica has for maritime surveillance four Sentinel series radars, Sentinel 50, Sentinel 100, Sentinel 200 and Sentinel 400. The number describes the transmitters' peak power. The radars are using FM pulse modulation and the minimum detection range is approx. 30m from the antenna. The instrumented range is mentioned to be up to 96 NM depending on the chosen profile. The size of the target is not mentioned. The radar is able to track more than 1000 track simultaneously. The radars are fully compliant with IALA V-128 recommendations for radar detection. Sentinel systems are operating in a large number of projects. The flexibility of configurations helps to cover customer demand in terms of power, architecture, installation and performances (GEM Elettronica, 2017).

Frequency band	Azimuth coverage	Beam width ↔/↕	Automatic detection/ tracking	Range accuracy/ resolution	Interoperability	Detection capabilities (sea state 3)		
X	360º	X-band ↕ 11º ↔0,35º	over 1000	12-18m/ not mentioned	NTR	Rubber boat	Patrol craft	Large ship
						Max. instrumented range is mentioned up to 96 NM depending on chosen profile		

Table 31: Sentinel specifications

Terma

Terma SCANTER family radars provides fully automatic surveillance and early detection and tracking of multiple simultaneous air- and surface targets. SCANTERs' extended horizontal detection range in mentioned to be up to 96 NM which means that one SCANTER radar can provide up to 98.000 km2 of situational awareness. There are three options for short-range surveillance radar category (SCANTER 2000, 4000 and 5000). The SCANTER 5000 Series radar is specifically designed for Vessel Traffic Services (VTS) and Coastal Surveillance Systems (CSS) applications. The SCANTER 5000 VTS & CSS radar provides reliable sea surface surveillance and detects the smallest non-cooperative targets during extreme environmental conditions. SCANTER radars provide early warning and tracking of non-cooperative targets. For SAR operations SCANTER provides track and share target positions functionality and combination of simultaneous detection of small surface targets and helicopter control. The radar can optionally be supplied with Doppler-based processing for enhanced long-range, fast moving target detection.

With both digital and analogy interfaces, the SCANTER 5000 Series is easily integrated with both new and existing surveillance and safety systems, which gives flexibility for potential customers.

In CSS applications, the SCANTER 5000 is mentioned to be an essential tool for dependable detection of:

- Smugglers in very fast boats
- Illegal immigrants traveling in small, slow boats
- Boats and jet skies with hostile intentions e.g. piracy
- Illegal fishing
- Search and Rescue operations

Frequency band	Azimuth coverage	Beam width ↔/↕	Automatic detection/ tracking	Range accuracy/ resolution	Intero-perability	Detection capabilities (sea state 3)		
X	360º	not mentioned	Mount of targets is not mentioned	High	Mentioned to be easily integrated with both new and existing surveillance and safety systems.	Rubber boat	Patrol craft	Large ship
						Max. instrumented range is mentioned, 96 NM		

Table 32: Scanter 5000 specification

The SCANTER 5000 Series has been deployed at major ports, including Hong Kong, Hamburg, and Singapore, and used by coast guards in Norway, Spain, and Colombia. (Terma, 2017)

Surveillance systems

Kongsberg

Kongsberg has developed the Norcontrol Coastal Surveillance Systems, which creates the real-time Common Operating Picture/Recognised Maritime Picture by providing detection, classification

and identification of cooperative and non-cooperative vessels. The idea is to have the information early enough for tasking the reaction assets. The Norcontrol C-Scope Management Information System - Coastal (CSMI) is a tool for managing data collected on a daily basis. The CSMI enable classifying of vessels, highlight vessels of interest, and retrieve data on any past incidents and accidents. (Kongsberg, 2019)

According to Kongsberg the Norcontrol Surveillance System can assist coastal authorities to (Kongsberg, 2019):

- Improve security of the maritime domain and coastline
- Detect vessels at long ranges
- Identify and classify vessels
- Highlight vessels of interest
- Visualize land-based reaction forces with the maritime picture
- Prevent ships from entering dangerous, sensitive, prohibited or restricted areas
- Prevent illegal immigration, drug trafficking and smuggling
- Detect oil spills with radar and/or satellite images
- Coordinate Search and Rescue and oil spill clearance/containment operations
- Integrate Blue Force Tracking

Raytheon

Raytheon SMARTBLUE is the latest command and control (C2) system, engineered by Raytheon Anschütz. It has been specifically designed for maritime situational awareness, collision avoidance, asset protection and security.

SMARTBLUE is based upon open "software architecture". Customers benefit from the flexibility to pick and choose from a broad range of surveillance sensors depending on their specifications and budget. Additional sensors and functions can be integrated to provide a fully comprehensive safety, environmental and security management system which in most cases, exceeds safety and security standards whilst at the same time, improving efficiency, reducing security and environmental risks and insurance premiums. (Raytheon Anschütz. 2019)

About the Short range radars and surveillance systems

On short ranges radar markets, there are several manufacturers and different type of radars. In this analysis, some of them are presented, their advantages or performance is presented in a table as an example of existing systems on the market. To rank the systems in order of preference in an objective way is impossible with the information based on public sources. In that perspective this chapter of the market analysis provides the basic information of some key products on the market and their as an option for RANGER's PE-MIMO radar.

Being in operational use and proven efficiency is always an advantage on radar markets. The systems introduced in this deliverable are outcome of long period testing, developing and lessons learned process. They all have already developed a wide ranges of different features according the customers' needs and in that perspective have an edge over MIMO radar.

On the other hand, RANGER MIMO is totally new product which represents novel technologies. Corresponding systems were not found in public sources, which might give input that RAGER is building a ground-breaking system for maritime surveillance. Theoretically, the technique is proven and after proving its capabilities in live validation test it's ready for the markets. However, this new technology is fore sure under investigation in several radar manufacturer.

7.1.2 Patrol Boats

The effectiveness of surface vessel patrols for maritime surveillance is related to the size and capabilities of the vessel. Often, the main surveillance system is the navigational radar. The key producers of vessel-mounted versions are the same that develop surveillance radars and systems. Navigational radars have better range accuracy and resolution, but smaller surveillance areas.

For surveillance purposes, patrol boats usually have navigational radars, AIS systems, and optoelectronic systems. Larger vessels may also have air surveillance radars and capabilities for underwater surveillance. Navigational radar control units are often capable of sensor fusion (sensors on-board the vessel), and at a minimum level, AIS targets are displayed on the radar operator screen. (Raymarine 2019)

Surface vessel mounted systems are capable of surveillance areas that vary from a few nautical miles to 96 nautical miles (NM), by a surveillance system that has an X-band radar for surface and air targets (Radarturorial 2019). The maximum surveillance distances are for air targets only. Additionally, the total coverage of surveillance is related to vessel route and speed. With a cruising speed of, for example, 17 knots (KN), a patrol vessel can cover approximately 400 NM in 24 hours and thus, depending on the tracking area of its surveillance system, antenna height, and target size it can cover a mathematical surveillance area from 30 000km² to 80 000 km².

The main advantage of patrol boat surveillance is that it is capable of visual identification of interesting targets that its on-board or other sensors have detected. This increases the importance of patrol boat surveillance. The operational costs of patrol boat surveillance are high compared to radar surveillance only. Solely the personnel costs are high as a vessel patrolling for 24/7 needs at least two watch crew.
In table 29, some of Mediterranean nations patrol boats' capabilities are described as an example. The objective comparison of naval surveillance system based on public sources turns out to be impossible due the provided information varies too much.

	Italy		Greece	Portugal[9]	Spain
Class/Type	Dattilo-class	Bruno Gregoretti	Missile Boat Sa'ar 4,5	Viana do Castello	Trolla
Crew	41	31	53	32	12
Cruise Speed (Knots)	13	15 Kn	19	20	NTR
Surveillance/ Navigation Radars	ARPA, Hensoldt Sharp Eye, Sea Dark 1x IRST	2x Furuno	Thales Neptune ELM 2258 A	Furuno FAR 3230 FAR 3220	KODEN MD3840
Processing System	NTR	C4I ASTIM Thermonav	NTR	NTR	NTR

Table 33: Example of Patrol boats used in Mediterranean area

7.1.3 Satellite Surveillance

Space assets are an important tool for strengthening the EU's capacity to protect its maritime security interests, including maritime surveillance. Several EU agencies have integrated satellite technology in their maritime surveillance activities.

The European Commission entrusted on 2015 EMSA the operation of the maritime surveillance component of the Copernicus security service. According to the agreement, EMSA will use Copernicus Sentinel 1 and other satellites' space data, combined with other marine data sources, for efficient monitoring of marine areas of interest. (Copernicus 2019). According to European Commission (2016, 2) "The goal of the Copernicus Maritime Surveillance Service, managed by the European Maritime Safety Agency (EMSA), is to support its users by providing a better understanding and improved monitoring of activities at sea that have an impact on maritime safety and security, fisheries control, marine pollution, customs and general law enforcement as well as the overall economic interests of the EU".

[9] In Portugal, the coast guard role is performed by several government agencies that, together, form the Maritime Authority System. For this table one Marinha vessel was selected to give an idea of exsisting Patrol Boat class capabilities.

European Maritime Safety Agency (EMSA) offers satellite based CleanSeaNet for oil spill and vessel detection services in near real-time. The CleanSeaNet bases on Synthetic Aperture Radar (SAR) satellite images that provide night and day worldwide coverage from maritime areas. SAR is independent from fog and cloud cover. Data is processed to images and analysed for oil spill, vessel detection and meteorological variables. Optical satellite imagery can also be obtained on request, depending on the situation and the user's needs. Each coastal state has access to CleanSeaNet through a separate interface that allows them to view the ordered images. (EMSA 2017). Electro optical (EO) sensors cover 400 km by 400 km area in medium resolution and analysis is ready in maximum 30 minutes. The Earth observation data centre (EODC) has the capacity to acquire satellite images of 500 km wide and up to 1,600 km long. CleanSeaNet is mainly meant for oil-spill detection and Search and Rescue operations providing a detailed view of accident area.

Following Figure illustrates CleanSeaNet detection statistics from 2018. Dots on the map represent the spills with higher detection reliability level (red) and a lower detection reliability level (green). (EMSA 2019b).

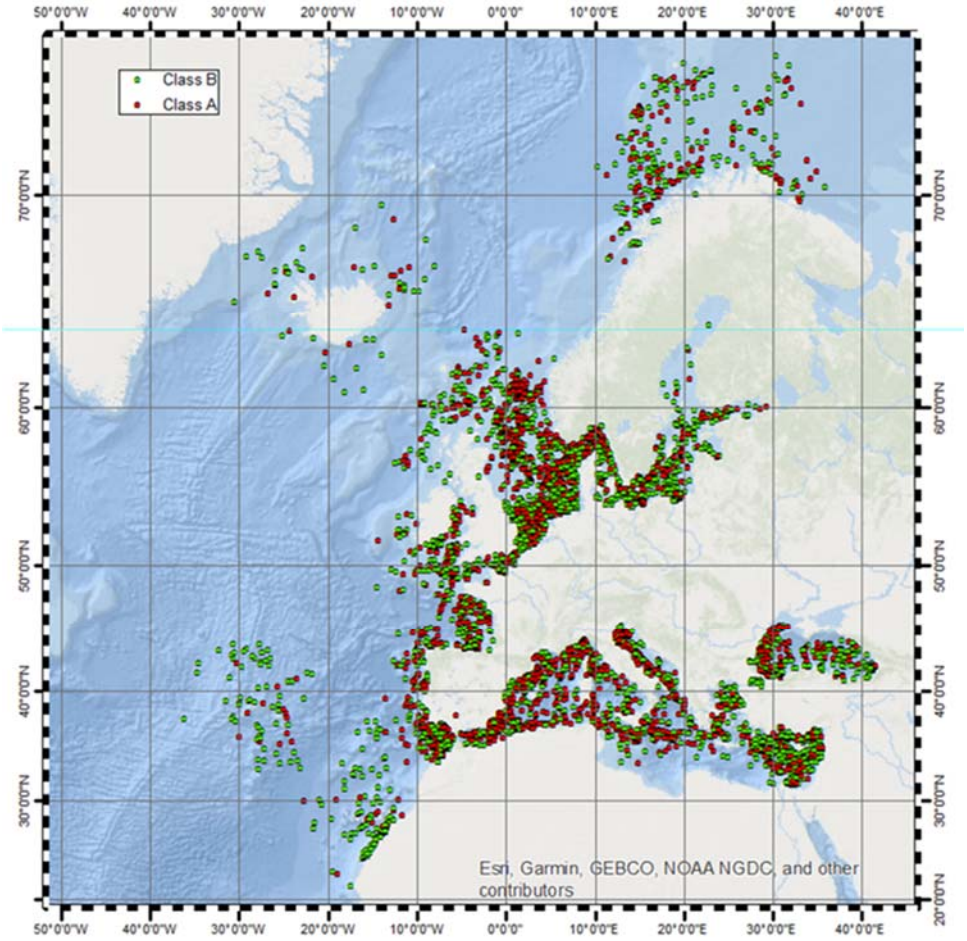

Figure 6: CleanSeaNet detection statistics from 2018 (EMSA 2019b).

EMSA provides Copernicus Maritime Surveillance Service (CMS) for six functional areas:

- Fisheries control
- Maritime safety and security
- Law enforcement
- Customs
- Marine environment polluting monitoring
- Support to international organisations and other activities

Following table presents delivery times for SAR and optical EO products.

Standard product		Value added product	
EO image		• Vessel Detection Service (VDS) • Feature Detection Service (FDS) • Oil Spill Detection	• Enriched Vessel Service (EVS) • Enriched Feature Service (EFS) • Wake Detection Service (WDS) • Activity Detection Service (ADS)
SAR	25 min	20 min	30 min
Optical	30 min	40 min	50 min

Table 34: Delivery times for SAR and optical EO products (EMSA, 2019a).

The classifications for EO SAR image products by resolution classes are very high resolution (VHR), high resolution (HR) and medium resolution (MR). Following table presents classes and their resolutions.

Class	Resolution
VHR1	$x \leq 1m$
VHR2	$1m < x \leq 4m$
HR1	$4m < x \leq 10m$
HR2	$10m < x \leq 30m$
MR1	$30m < x \leq 100m$

Table 35: Resolution classes for EO SAR products (EMSA 2019a).

Resolution classes for EO optical image products are VHR1 and VHR2. VHR1's resolution is ≤ 1 m while VHR2's resolution is from 1 m to 4 m. EO SAR image characteristics can be found from EMSA's Copernicus Maritime Surveillance Product Catalogue on EMSA web pages.

EMSA's value-added products for earth observation contains vessel detection, feature detection, activity detection, oil spill detection and wind and wave information. EMSA's Copernicus Maritime Surveillance Product Catalogue presents these products and their details.

Next table presents as examples value-added products: vessel detection and activity detection.

Value-added product	Use cases
Vessel detection	Detection and tracking of vessels of interest Detection of non-reporting, missing vessels or vessels in distress Vessel type classification, e.g. fishing vessel, reefer, sailing vessel, etc. Monitoring of vessel movements inside restricted areas
Activity detection	Fishing grounds monitoring Fishing activity pattern Vessels towing cages Rendezvous at sea and transhipment operations At-sea refuelling Remote port and coastal monitoring Detection of potential aggregation points for illegal embarkation Detection of illegal discards Hijacked ship Skiffs/speed boats approaching vessel Monitoring of activities/change detection along the coastline Ice monitoring

Table 36: Example of value-added products (EMSA 2019a).

Copernicus Earth Observation products are integrable with other EMSA maritime information applications as well as other external data sources, such as Automatic Identification System (AIS), Long Range Identification and Tracking (LRIT), and Vessel Monitoring System (VMS). The additional information may include information such as the vessel's position, identity and tracking information. Copernicus Maritime Surveillance (CMS) supports maritime safety and security through tracking objects at sea, monitoring incidents and accidents and vessel location and identifying. (EMSA 2019a).

Smart Eyes on the Seas (SEonSE) is the e-GEOS[10] maritime surveillance platform that provides a way to gain access to maritime information. SEonSE allows a continuous global monitoring service of the seas. e-GEOS operates a radar centre infrastructure that processes and analyses data from most of the commercially available radar and optical satellites 24/7. SEonSE provides on-demand monitoring services for special requirements such as oil spills, illegal fishing, anti-piracy, intelligence and security. For ship detection and tracking, SEonSE provides geological location with date and time of detection, estimated size, speed and direction. Vessel ID is obtained by the automatic correlation of Earth Observation data with data from the cooperative systems (e.g. AIS, LRIT, and VMS). Other services that SEonSE provide are strategic surveillance for intelligence and security, oil spill monitoring and predictive evolution, ice monitoring and access to geospatial big data analytics and reports. (e-GEOS 2019).

The following table shows an example of satellite capabilities comparing vessel identification, oil leak detection, and identification and tracking systems in case anomaly detection.

		Satellite Ship Detection	**Satellite Oil Spill Detection**	**Identification and Tracking Systems (AIS, SatAIS…)**
AOI (Area of Interest)	Entering	x	x	x
	Exiting	x	x	x
	Approaching			x
	Distance to shore	x	x	x
Behaviour	Rendezvous	x		x
	Sudden change of heading			x
	Sudden change of speed			x
	Speed threshold	x		x
	No movement	x		x
Pre-defined list	Illegal, Unreported, and unregulated (IUU) fishing			x
	Own fleet			x
Knowledge discovery	Persistent/Recurrent feature detection	x	x	x
	Heatmap	x	x	x
Information consistency	Vessel dimensions comparison	x		x
	Change of IMO name, destination during the voyage			x

Table 37: Example of satellite's capabilities in anomaly detection (EUCISE2020 2018).

COSMO-SkyMed consist four radar satellites for Earth observation founded by the Italian Space Agency and the Italian Ministry of Defence. Its purpose is to monitor the Earth for the sake of emergency prevention, strategy, scientific and commercial purposes, and providing data on a global scale to support a variety of applications among which environment protection, defence and security and maritime surveillance. The COSMO-SkyMed satellite main payload is an X-band, multi-resolution and multi-polarization imaging radar, with various resolutions (from 1 to 100 meters) over a large region. (COSMO Sky-Med 2019).

[10] e-GEOS is a company owned by Italian Space Agency (ASI) by 20% and Telespazio by 80%.

TerraSAR (Germany) and SPOT IMAGE (France) have a mix of optical and radar capabilities for vessel detection and classification and maritime surveillance for border security. The French GALILEOCEAN improves border security by optimizing the use of Galileo for maritime positioning. Germany`s projects ShipDetec focuses countering piracy, smuggling, illegal migration and IUU fishing while DeMarine's focus is on improving the security of ship routes. Italy`s Safety in Sea Traffic is specialized in the development of advanced satellite navigation technologies. (Bosilca 2016). According to Bosilca (2016) EMSA relies on data collected by the Copernicus Sentinel 1 satellites to monitor sea surface inside and outside the EU. The European Union Satellite Centre (SatCen) enables EU external action in third countries by providing up-to-date satellite imagery.

CN News reports that China has launched a new high-tech high-resolution imaging satellite to safeguard China's maritime rights and interests. The Gaofen 3 high-resolution Earth observation satellite was launched with the intent of providing 24-hour observation of China's territorial seas and to safeguard its maritime interests. The satellite is equipped with a radar system and 12 imaging modules that capture images from space with a resolution down to 1 meter, according to the State Administration of Science, Technology and Industry for National Defense, which oversees China's space programs[11].

Gaofen-3 has a maximum resolution of 1m and a maximum swath width of 650km, from a 730x730km orbit. Even a pair of such satellites would not be sufficient to cover all the oceans' surface every day, but would be enough to find all ships in a relatively wide region of interest[12].

At EU level, satellite technology has numerous applications in various law enforcement systems supporting maritime surveillance activities such as (Bosilca 2016):

- Fisheries control
- Illegal immigration
- Border control
- Drug trafficking
- Weapon trafficking
- Anti-piracy
- Human trafficking

The main obstacle to the use of satellite imagery, of which there is still considerable potential for improvement, is the considerable time difference between the satellite crossing and the transmission of satellite imagery data to Frontex and the National Contact Centres (NCC). In order to add real value to satellite imagery, the results must be delivered within minutes or at least hours. Another problem is that, in civilian applications such as border control, access to high-resolution satellite imagery is restricted, which does not allow full use of existing capabilities. (Seiffarth 2013).

Satellite systems are an essential instrument for consolidating the capacity of the EU to secure its maritime security interests in the maritime surveillance. The benefit of using satellites is considered improved efficiency combined with lower operating costs. Traditional control methods (e.g. on-board inspections) will not be abandoned, but will be simplified and centralized through the introduction of new technologies. (Bosilca 2016).

7.1.4 Remotely Piloted Aircrafts

There are over 2000 different type of RPAS systems in global, over 660 manufacturers in nearly 60 countries (Blyenbugh 2016). There are several different types of classifications for RPAs. Following table present one example of those.

	Short range	Medium range	MALE	HALE	UCAV
Weight (kg)	50-250	150-500	500-1500	2500-5000	1500-10000

[11] https://gcaptain.com/china-launches-high-resolution-maritime-surveillance-satellites/
[12] https://satelliteobservation.net/2016/09/20/the-chinese-maritime-surveillance-system/

Ceiling Alt. (m)	3000	5000	8000	20 000	10 000+
Operation time (h)	3-6	6-10	24-48	24-50	5-18
Distance (km)	30-70	70-200	>500	>2000	>2000
Price (€)	100 000-600 000	Millions	Tens of millions	Several tens of million	Several tens of million

Table 38: RPAS classification example

MALE stands for Medium Altitude Long Endurance, HALE stands for High Altitude Long Endurance and UCAV for Unmanned Combat Aerial Vehicle.

EMSA provides maritime surveillance services with Remotely Piloted Aircraft Systems (RPAS) by request for authorities belonging to EU Member states, Iceland, Norway and the European Commission. EMSA provides Remotely Piloted Aircraft Systems (RPAS) for maritime surveillance operations free of charge to the EU Member States, candidate countries and European Free Trade Association (EFTA) countries. (European Maritime Safety Agency, 2019).

RPAS services include, for example, a) monitoring of marine pollution and emissions, b) detection of illegal fishing, drug trafficking and illegal migration, and c) search and rescue (SAR). RPASs equipped, for example, with optical and infrared cameras, radar, gas sensors and AIS sensors. Aircraft currently available have a durability of 6-12 hours. There are three types of RPAS for different operational purposes: 1) Medium size with long endurance; 2) Larger size with long endurance and a comprehensive set of sensor capabilities and; 3) A Vertical-Take-Off-and-Landing (VTOL). (European Maritime Safety Agency, 2019).

In September 2018, Frontex launched RPAS testing for border control in Greece, Italy and Portugal to monitor the European Union's external borders. Frontex examines RPAS monitoring capability for Medium Altitude Long Endurance (MALE) and evaluates cost effectiveness and robustness.

In the simplest form, RPAS systems can be divided into two categories related to the principle of their retention in the air. Following table presents comparison of fixed wing and rotary wing RPAS features.

Fixed wing	**Rotary wing**
Large intelligence area – high altitude	Smaller intelligence area – low altitude
Low power consumption - long operating time	High power consumption - short operating time
High payload take-off mass	Small payload take-off mass
Fast moving from one waypoint to another	Slow moving from one waypoint to another
Good resistance to wind load	Worse resistance to wind load
High space requirement on the ground - runway or parachute	Small space requirement on the ground - VTOL
Laborious integrating a new payload	Easier integrating a new payload
De-icing systems are possible	No de-icing systems in use
Long education	Short education
Low fault sensitivity	Higher fault sensitivity - more moving parts

Table 39: Comparison of fixed and rotary wing RPAS (Insta ILS 2018):

Next table presents some fixed wing RPAS systems for maritime surveillance.

	Hermes 900	**Falco EVO**	**Zephyr S/T**	**DVF2000ER**	**Scan Eagle**	**Patroller**	**AR5**
							
Manufacturer	Elbit System (IL)	Leonardo (IT)	Airbus (GE/UK)	Airbus – Survey Copter (FR)	Insitu / Boeing (USA)	Safran (FR)	Tekever (PT)
Category	MALE	MALE	HALE/HAPS (High Altitude Pseudo-Satellite)	MINI	MINI	MALE	MAME (Medium Altitude Medium Endurance)
Payload capacity	450 kg	120 kg	65 kg /S 140 kg /T	2 kg	18 kg	250 kg	50 kg
Operation time	36-40 hours	20 hours	30 days	7 hours	16-24 hours	20 hours	20 hours
Range	250-300 km	200km	1800 km/S 2300 km/T	50 km	100 km	200 km	1400 km
Max. Altitude	9.1 km (30000 ft.)	6 km (20000 ft.)	21 km (70000 ft.)	3 km (10000 ft.)	6 km (20000 ft.)	6 km (20000ft)	
Payloads	- Nose camera (pilot view) - EO/IR - SAR - COMINT - ATC Voice comm	- Nose camera - EO/IR - SAR - AIS transponder	- Nose camera - EO high resolution - IR (Long/Medium/Short Wave) - (SAR not yet, but planned)	- EO/IR	- EO/IR - Laser RF - AIS - SAR	- EO/IR - AIS - SAR - COMINT	- EO/IR - AIS - Radar - SAR

Table 40: Examples of fixed wing RPAS features (Elbit, Leonardo, Airbus, Boeing, Insitu, Safran, Tekever 2019.

Examples of Rotary wing RPAS features are shown in the following table.

	MQ-8B Fire Scout	**V-200 Skeldar**	**R-350**	**Camcopter S-100**	**AWHERO**	**VSR700**
						
Manufacturer	Northrop Grumman (USA)	SAAB (UMS Aero Group) (SE/SW)	UMS Skeldar (SW/SE)	Schiebel (AI)	Leonardo (IT)	Airbus (FR)
Category	Rotary wing	Rotary wing	Rotary wing	Rotary wing	Rotary wing	Rotary wing
Payload capacity	272 kg	40 kg	12 kg front, 30 kg below	50 kg	85 kg	100 kg
Operation time	6-7 hours	5 hours	2 hours	5 hours	6 hours (at 35 kg payload)	10 hours
Range	200 km	120 km	25-80 km			
Max. Altitude	6,1 km (30000 ft.)	3 km (10000 ft.)	2,5 km (8200 ft.)	5,5 km (18000 ft.)	3 km (10000 ft.)	6 km (20000 ft.)
Payloads	- EO/IR - Radar - AIS - Laser RF	- EO/IR - AIS - SAR	- EO/IR - LIDAR - AIS	- EO/IR - SAR - LIDAR (Laser Imaging Detection and Ranging) - AIS	- EO/IR - Radar - SAR - LIDAR - AIS - IFF	- EO/IR - Radar - COMINT - AIS - + other

Table 41: Examples of rotary wing RPAS features (Northrop Grumman, UMS Aero Group, Schiebel 2019).

RPAS can complement and/or replace existing resources in a cost-effective way. RPAS may be used example for:

- Pollution monitoring and response
- Real time ship emission checks
- Search and Rescue (SAR)
- Fisheries control
- Customs Control
- Border Control
- Law enforcement

Equipped with suitable sensors, RPAS is capable of detecting marine pollution when carrying out targeted or routine marine surveillance operations. RPAS can confirm the pollution that was initially detected by other resources (such as a satellite) and collect water and pollution samples. Real-time ship emission control is an apparent way to do with aeroplanes flying an interesting ship's emissions plume. Because there are no people on board, RPAS is the perfect resource to perform this type of task and meet the operational need. For the Maritime community, RPAS use would bring new abilities to the implementation of legislation on emissions from ships and carry out such duties. (EMSA 2016).

For search and rescue organizations, RPAS is a tool to improve search capabilities in large SAR areas for improved durability on manned aircraft and faster response times compared to vessels. In adverse weather conditions, RPAS will perform better than manned aircraft and vessels, and the associated risk to on-board personnel will be reduced. SAR operations may be conducted away from the shore in locations with little or no communication coverage. (EMSA 2016). "RPAS can be used as communication relay platforms to support the coordination of resources involved in the search and rescue operations" (EMSA 2016, 4-5).

RPAS flight endurance, range and hidden features are important in targeting and tracking fishing vessels that may be involved in illegal activities such as fishing activities in restricted areas. The main advantage of Fisheries control authorities of using the RPAS system would be the detection of illegal activities, which nowadays is difficult to do with existing means or cost-effective manner.

What comes to customs control, border control and law enforcement, the advantage of using RPAS in general maritime surveillance and intelligence and surveillance of suspicious vessels, is to provide a communications relay for offshore tasks, and longer operating time and range compared to manned resources.

The main benefit of using RPAS from an operational point of view is that RPAS offers greater operational flexibility over conventional resources. Enhanced operational performance united with cost benefits is a tempting alternative to end-users.

7.1.5 Lighter than air (LTA) systems

Lighter than air system's remote control location can be positioned in a marine vessel. The operating time is not limited by the amount of fuel or the capacity of the batteries. Operation does not require flying: payload controlling is mainly stationary. The floating aircraft can be lifted to a height of 100-150 m with payload up to 18 kg.

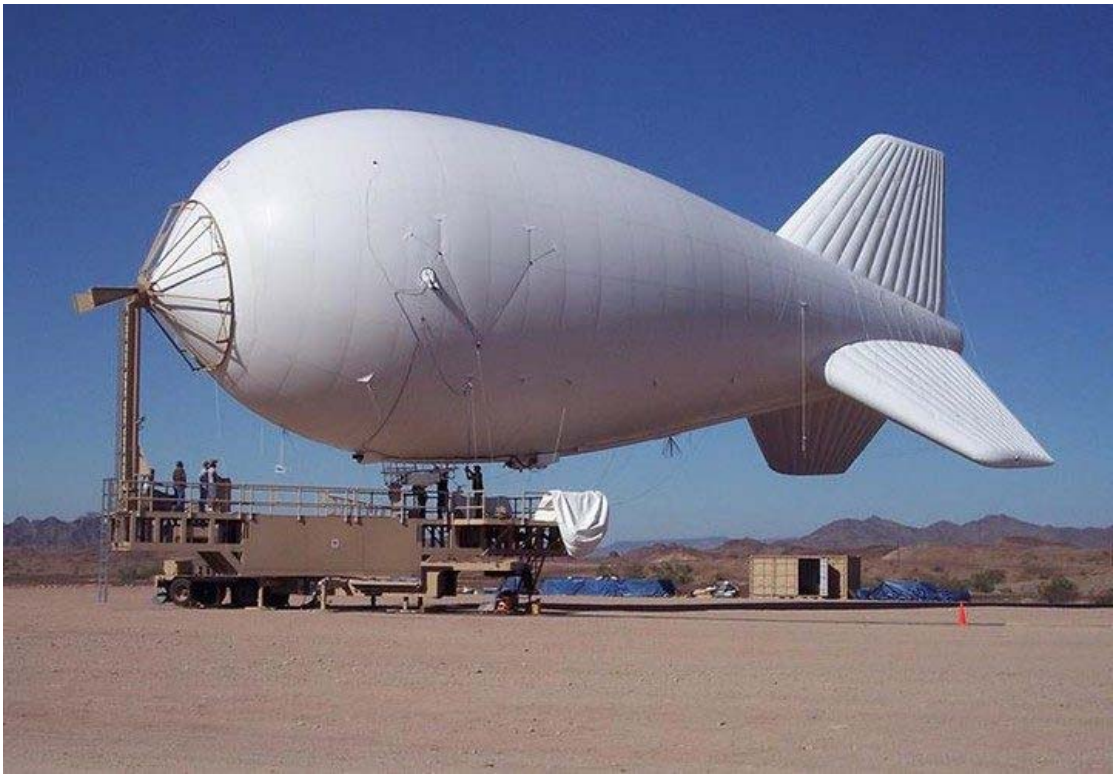

Figure 7: Lockheed Martin Unmanned Aerostat lighter than air model 74K (LockheedMartin 2019).

Airship is powered, steerable aircraft that is inflated with a gas lighter than air. Airships are divided into three main types (by keeping them in shape): 1) rigid bodies (aluminium body) like zeppelin; 2) semi-rigid hull; and 3) unbraced. Typical in the airtime is 20-30 days with 5 to 7 sensors: - Electro Optical (EO), infrared (IR), Synthetic Aperture Radar (SAR), Laser RF, and Laser illumination. Acoustic sensors are often included for weapon and projectile detection.

Following table gives an example of two Aerostats/Airships and their features.

	74K	**420K**
Manufacturer	Lockheed Martin	Lockheed Martin
Length	35m	64m
Payload	500kg	1000kg
Max. Ceiling Altitude	1500m	4600m
Operation time	30 days / 150km (Line-of-sight, LOS)	30 days / 240km (Line-of-sight, LOS)
Operational wind component	33 m/s	33 m/s
Radar horizon		275 km

Table 42: Comparison of Lockheed Martin 74K and 420K airships (Lockheed Martin 2019).

7.1.7 Maritime Patrol Aircrafts

A maritime patrol aircraft (MPA) is a fixed wing aircraft operating for long durations over sea and coastal areas. Typically, MPAs are fitted with radar for surface ship movement detection and tracking, infrared cameras (Forward Looking Infrared, FLIR).

Maritime Surveillance Aircraft (MSA) provides maritime surveillance solution designed for Search and Rescue (SAR), anti-piracy patrols and coastal and border security MSA uses proven technologies to provide multi-mission surveillance capabilities. (Writers 2014).

The main difference between MPA and MSA might be that the MPA is normally armed and the MSA is not. MPA normally carries torpedoes, air-to-surface missiles, sonobuoys, acoustic system and is capable for ASW operations.

The table below lists top ten maritime patrol aircraft, according to Naval Technology magazine (2019).

Type	Manufacturer	Sensors/Missions[13]	Range [km]	Operation time
P-3 Orion	Lockheed Martin	Maritime / over-land patrol, anti-submarine warfare, anti-piracy, anti-terrorism, drug interdiction and the prevention of illegal immigration	8944	16 h
P-8A Poseidon	Boeing	maritime patrol, anti-submarine and anti-surface warfare, intelligence, surveillance and reconnaissance (ISR) missions, multi-mission surface search radar	7240	
P-1	Kawasaki Heavy Industries	Active electronically scanned array (AESA) radar, advanced combat direction system, magnetic anomaly detection, infrared/light detection systems, detection and tracking of submarines and small vessels.	8000	
Swordfish	Saab	Maritime ISR, maritime counter-terrorism, anti-piracy, anti-submarine warfare (ASW) and anti-surface warfare (ASuW) missions. Sensors: multi-mode maritime surveillance radar, electro-optical sensors with laser payload, automatic identification system (AIS), identification friend or foe (IFF), electronic warfare and self-protection system, SATCOM, and tactical data links.	7400	11,5 h
CN-235/HC-144	Airbus Defence & Space Military Aircraft	Fully integrated tactical system (FITS) can be integrated with a variety of mission sensors for conducting complex surveillance missions.	4200	11 h
ATR 42/72 MP	Leonardo Aircraft	Variety of missions such as identification and tracking of vessels, maritime and coastal surveillance, search-and-rescue (SAR) and pollution detection missions.	3741	11 h
AN-74 MP	Antonov	MPA, can also be used for SAR, electronic and radio reconnaissance, and the detection of marine pollution	3704	8-9 h
C-295 Persuader	Airbus Defence & Space Military Aircraft	Maritime patrol, EEZ surveillance, SAR and anti-submarine and anti-surface warfare missions. ESM/electronic intelligence, weapon system, a sea pollution detection system. Sensors: radar, EO/IR turret, acoustic system, magnetic anomaly detector (MAD), AIS, IFF interrogator.	3333	> 8 h
EMB-145 MP	Embraer	Maritime patrol and AsuW and ASW missions.	3020	

Table 43: Maritime patrol aircrafts (Naval Technology 2019; Shephard 2018).

On the market there are multiple MPA manufacturer and different type of MPA's, but for this deliverable three different size MPA from Naval Technology top 10 list has been selected to get

[13] Please remember that RANGER is for non-military use.

better understanding about the MPA/MSA performance and capabilities. The chosen ones are P8/1, ATR 72MP and outside the top ten list Saab GlobalEye instead of Swordfish because the GlobalEye presents the newest technology and innovations in maritime surveillance from the air.

ATR 72 MP is based on the ATR 72-600 twin-engine turboprop short-haul regional airliner. The design of ATR 72MP is mentioned to enable roles of maritime patrol, search and identification of surface vessels, Command, Control and Communication, ISR, Intelligence, Surveillance and Reconnaissance, Search and Rescue missions, the prevention of narcotics trafficking, piracy, smuggling, territorial water security and monitoring and intervention in the event of environmental catastrophes. The mission system includes four operator stations, using a Leonardo's Airborne Tactical Observation and Surveillance (ATOS) mission system. The system integrates three main sensors, the Star Safire HD electro-optical turret; the Selex ES Seaspray 7300 electronically-scanned array search radar and the self-protection suite based on the Elettronica ELT800V2 ESM. C4I system consists of multi-datalink fully integrating Link 16, Link 11, Satcom Ku/Ka, VORTEX, VMF and Radar Classifier, in addition to ESM ELINT (Electronic Support Measures – ELectronic INTelligence) capabilities. (Navy Recognition 2017)

The Saab GlobalEye roll out was in February 2018 and had its first flight in March 2018. The GlobalEye sensors includes Erieye ER (Extended Range) radar, Seaspary 7500E maritime surveillance radar, electro-optical sensor (Star Safire 380HD according to unverified information), ESM/ELINT, AIS and IFF/ADS-B. All the sensors are connected to command and control system which could also be operated remotely from command centre. (Lentoposti 2018).

The Erieye ER is in S-band operating, active electronically scanned array (AESA) that use gallium nitride (GaN) technology to scan air and surface. The radar provides very long-range detection against difficult to discern targets with very fast detection rates and the ability to handle numerous contacts. The Erieye ER detection or instrumental ranges has not made known but the ER radars predecessor Saab 2000 Erieye is mentioned to have instrumental range of 450 km and detection range of 350 km for fighter aircraft size target. (Air Force Technolgy) According to Erik Windberg, Senior Director of Saab Airborne Surveillance, the Erieye is capable to detect the maritime targets such as jet skis and rib boat over 100 NM distance and the land targets detection capability is also good, but any numbers were not given. (Erik WIndberg).

The Seaspray 7500E X-band multi-mode radar which combines an Active Electronically Scanned Array (AESA) with a Commercial Off-The-Shelf (COTS) processor. AESA technology and flexible waveform generation capability enables Seaspray 7500E to deliver peak performance in all modes. The use of multiple low power, solid state Transmit/Receive Modules (TRM) is mentioned to make the Seaspray 7500E radar more reliable than conventional radar systems. By using the mechanical and Composite Electronic scanning (CEMS) the radar performance in detecting small targets, such as Fast Inshore Attack Craft (FIAC) in high sea states is mentioned to be superior. The maximum instrumental range of the radar is mentioned to be 320 NM. (Leonardo.2019c). The Seaspray radar is located underneath the aircraft and supports on surface surveillance, while an electro-optical turret under the chin of GlobalEye provides a day/night visual image within a 360° arc.

The Flir Systems electro optical (E/O) sensor used on GlobalEye provides image stabilisation and ultra-long range imaging performance with digital HD video. It has day/night capability and allows the operator to achieve visual identification and gather evidence, which can be useful post-flight. (Air Force Technology 2018) The type of the E/O sensor is not confirmed but according to some sources it might be Star Safire 380HD.

Saab has chosen the Bombardier Global 6000 as a platform because the requirement we see in the market meant we needed a platform with long range and endurance. The Global 6000 is an ideal special-mission aircraft from a design and flight envelope point of view because it brings those attributes and smooth handling, plus a crew environment designed for the VIP business traveller.

The long mission times mean it is important to provide the operators with the best working environment to maximise their performance. (Air Force Technology 2018) Including the pilots' altogether nine operators' could work in the cabin and as mentioned earlier all the systems could be used remotely from land based operation centre.

The P-8 Orion belongs to MPA category and is designed mainly for anti-submarine warfare. The P-8 is intended to replace the P-3 Orion as the front-line anti-submarine warfare aircraft. For the ASW operations P8 is equipped with an active multi-static and passive acoustic sensor system, inverse synthetic aperture radar, new electronic support measures system, new electro-optical/infrared sensor and a digital magnetic anomaly detector. (Military.com 2019)The AN/APY-10 RADAR system is a multi-mission maritime and overland surveillance RADAR. It is capable of performing long-range surface search and target tracking, periscope detection, ship imaging and classification using synthetic aperture radar (SAR) and inverse synthetic aperture radar (ISAR). This radar system has a colour weather mode capable of detecting in all weather conditions. The performance of the maritime target detection capability is mentioned to be a radar cross section ranging from 1 to 10,000 square meters at 29 to 200 nautical miles. The AN/APY-10 is fully integrated into Boeing's Mission Control and Display System for control, display and data distribution on the Poseidon. The radar is also mentioned to provide ultra-high resolution imaging modes for maritime and overland operations. (Global Security 2019) The P-8 is armed with an internal five-station weapons bay, four wing pylons, two centreline pylons, all supported by digital stores management allowing for carriage of joint missiles, torpedoes and mines (Military.com 2019).

MPA costs

The MPA costs is compose of purchase price, operational costs €/hrs, maintenance costs, update costs etc., and every nation has their own way to calculate them. For example "*In Finland, the cost of a flight hour covers everything from the salary of the Air Force Commander and the upkeep of air bases to maintenance tools and jet fuel*" (Puranen 2019). So in that perspective the real expenses of MPA is one of the hardest part to calculate. Anyway some figures were found for example Global 6000 normal business jet version costs around 60 million USD but it's still without any surveillance system. "Norwegian MOD, media reports during November 2016 have noted, intends to buy five P-8As at a cost of $1.1 billion. This gives the aircraft a unit price of between $300 million to over $400 million" (Armada International 2017). As a reference to that U.S Navy and Royal Australian Air Force made 2016 contract with Boeing for building 20 P-8A with the contract of $2, 5 billion (Boeing 2016) which means round US$125 million each.

7.2 Comparison with RANGER[14]

On the OTH market there is only a few option in the category where RANGERs' radar is located. Four main products are BAE HFSWR, ELM 2270, DXT Stardivarius and Raytheon HFSWR. All the OTH radar presented in this chapter use same High Frequency Surface Wave principle to detect the maritime targets behind the horizon as the RANGERs' use. Other technical differences between the systems could not be found due the limited information in public sources. For sure, each of them has their own advantages, which the customer has to valuate against their specific needs or requirements. All the radars mentioned in this chapter are in operative use as well as under the development process. Novel techniques will be used as they are found and in that perspective new version/generation is coming to the market.

[14] Again, it must be underlined that RANGER is for non-military use. And that many maritime surveillance methods presented here have somewhat dual use: both for military purposes and for civilian, including border control and SAR-operations. Thus, the comparison of the different methods can be difficult – often impossible. Nevertheless, a sophisticated reader can make his or her judgement and use this material to get an overview for the value of RANGER.

As mentioned China has operative HF radars, the knowhow and resources to develop radars for this category in deed. According the media China is developing OTH technology and new products or might update the existing ones but quite limited information is available.

As opposed to OTH markets, on short ranges maritime surveillance radar markets there are several manufacturers with different type of radars. The provided information varies form verbal description to detailed figures of the systems advantages so one objective table of the performance was not able to formulate. In this context, the description of the short-range radars provides the idea that for the customer there is a lot of systems to choose as an option for RANGERs' MIMO radar. Being in operational use and proven efficiency is always an advantage on radar markets. The systems introduced in this deliverable are outcome of long period testing, developing and lessons learned process. They all have already developed a wide range of different features according the customers' needs and in that perspective have an edge over MIMO radar. They all have their own advantage areas and the customer has to evaluate the benefits according the purpose, geographical location, needs, and the infrastructure where the system is belonging to etc.

On the other hand, RANGER MIMO is totally new product, which represents novel technologies. Corresponding systems were not found in public sources, which might give input that RAGER is building a ground-breaking system and will be the first on market with the MIMO technology. Theoretically, the technic is proven and after proving it's' capability in live validation test it's ready for the markets. However, this new technology is fore sure under investigation in several radar manufacturer.

The boat patrols capabilities for maritime surveillance is highly related to vessels size. The surveillance area varies according the manufactures announcements from some nautical miles up to 96NM. The biggest number belongs to system which is mentioned to be surveillance system with X-band radar for surface and air targets, which means that the 96 NM surveillance distance is for air targets. Even the surveillance area could be large the main advantage for boat patrolling is the capability to identify the detected suspicious target with its own decision and in SAR cases the command post and first asset is present immediately. The patrolling costs are exponential compared to radar surveillance. For 24/7 operating hour's means that the boat needs at least two-watch crew and pending on the vessels size, the time at sea varies from few days to months without logistical mooring. From the environmental point of view only the newest ships are able to use Liquefied Natural Gas (LNG) for sailing, which means that carbon footprint of the boat, patrolling has to take in account also.

The Israel Aerospace Industries Ltd. unit ELTA Systems is the only producer who has both the OTH radar and the short-range maritime surveillance radar. In that perspective the combination ELM-2270 0TH radar and ELM2226 compose a considerable challenger to RANGER. It is noteworthy to mention that in ELM combination there is no gap between OTH and short-range radars surveillance area.

The main obstacle to the use of satellite imagery, of which there is still considerable potential for improvement, is the considerable time difference between the satellite crossing and the transmission of satellite imagery data to Frontex and the National Contact Centres (NCC). In order to add real value to satellite imagery, the results must be delivered within minutes or at least hours. Another problem is that, in civilian applications such as border control, access to high-resolution satellite imagery is restricted, which does not allow full use of existing capabilities. (Seiffarth, 2013).

Satellite systems are an essential instrument for consolidating the capacity of the EU to secure its maritime security interests in the maritime surveillance. The benefit of using satellites is considered improved efficiency combined with lower operating costs. Traditional control methods (e.g. on-board inspections) will not be abandoned, but will be simplified and centralized through the introduction of new technologies. (Bosilca 2016).

Lighter than air system's remote control location can be positioned in a marine vessel. The operating time is not limited by the amount of fuel or the capacity of the batteries. Operation does not require flying: payload controlling is mainly stationary.

Traditionally, Maritime Situation Picture (MSP) has created using a variety of technologies and platforms, such as manned aircraft (helicopters / aeroplanes), Earth observation (satellite systems), and land based infrastructure and patrol vessels. Modern technologies and systems, such as RPAS, provide innovative and key features that can potentially provide an additional source of information and performance. They can bridge the gap between satellite-based information and locally acquired information. RPAS is a tool to reinforce existing resources and / or replace them in a more cost-effective way.

Maritime Patrol Aircraft (MPA) is an effective tool for surveillance purposes when discussing of accuracy, areal coverage and selection of surveillance equipment's. The Saab GlobalEye is the one from MPA class which could be seen as a competitor to RANGER. With approximately four GlobalEye unit and five crew the 24/7/365 operating hours could be possible. The wide range of surveillance systems (air, maritime and surface), the large surveillance area, C2/C4I systems and the capability for remotely operate the surveillance systems makes it considerable option for the customers. Naturally the nature of surveillance from the air makes the GlobalEye marketing extremely challenging for the supplier.

Conlusion

How to conclude such a vast and versatile analysis that had so many different aspects? Maybe by stating first that this versatility open possibilities, and that is precicely what this deliverable wanted to do: open up thinking of what the market is and what it can be.

We can look it as a greographical area and pinpoint locations and areas where RANGER solutions serves the best (as done in this analysis). We can also examine the organisations and entities that might be potential buyers of the solutions (done too). But we can also try to change thinking about our product, and see it as part of a whole business ecosystem (also done).

Nonetheless, above is second to the point that in market, the product does matter. Thus back to the very essence of RANGER: innovative and ground breaking solutions. Therefore, was very relevant the analysis of the competitors solutions, since it helps also to isolate the value of RANGER.

The value of RANGER is demonstrated perhaps best during the pilots (two in France and two in Greece). However, the true test awaits. It is now necessary to compare RANGER over time in an operational test of several weeks or months within teams of end users

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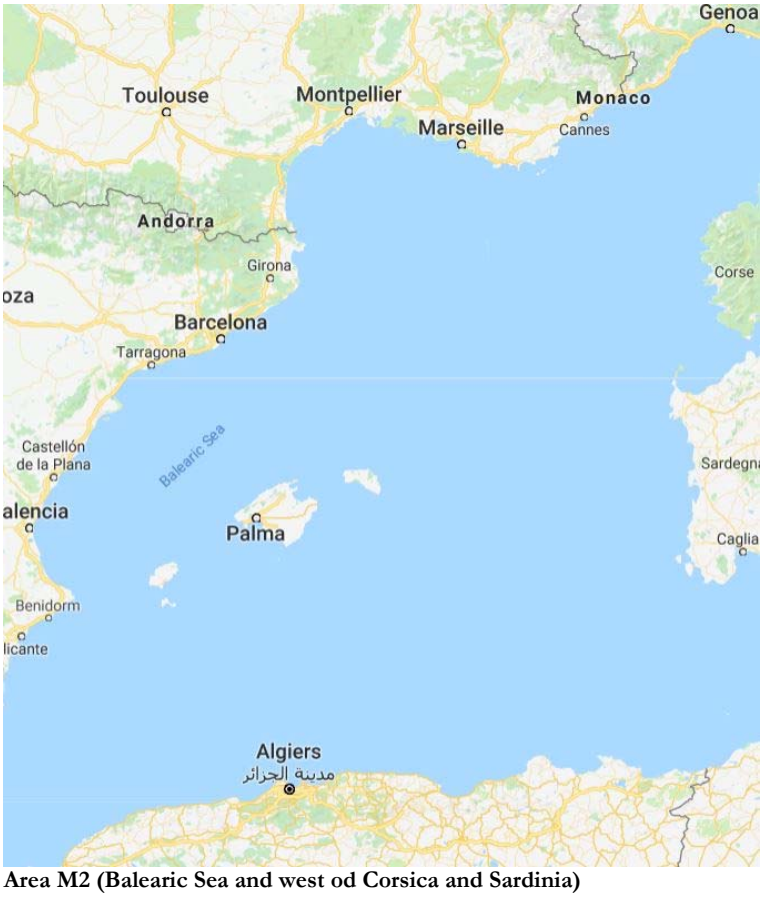
Annex A - List of Acronyms

Acronym	Meaning
ADS	Activity Detection Service
AESA	Active Electronically Scanned Array
AIS	Automatic Identification System
AOI	Area of Interest
ASCR	Advanced Coastal Surveillance Radar
ASW	Anti-Submarine Warfare
ASuW	Anti-Surface Warfare
ASP	Situation Awareness Picture
ATC	Air Traffic Control
ATOS	Airborne Tactical Observation and Surveillance
CEMS	Mechanical and Composite Electronic scanning
CMS	Copernicus maritime surveillance
DRDC	Canadian Department of National Defence
CMS	Copernicus Maritime Surveillance
CSMI	C-Scope Management Information System
CSS	Coastal Surveillance Systems
COMINT	Communications Intelligence
COTS	Commercial Off-The-Shelf
C2	Command and Control
EEZ	External Economic Zone
EFS	Enriched Feature Service
EFTA	European Free Trade Association
ELINT	ELectronic INTelligence
EMSA	European Maritime Safety Agency
EO	Electro optical
EODC	The Earth observation data centre
EU	European Union
ER	Extended Range
ESM	Electronic Support Measures
EVS	Enriched Vessel Service
FDS	Feature Detection Service
FIAC	Fast Inshore Attack Craft
FITS	Fully integrated tactical system
FLIR	Forward Looking Infrared
FM	Frequency Modulation
GaN	Gallium nitride
HALE	High Altitude Long Endurance
HAPS	High Altitude Pseudo-Satellite
HF	High Frequency
HFSWR	High Ferquency Surface Wave Radar
HR	High resolution
IASR	Inverse Synthetic Aperture Radar
IALA	International Association of Lighthouse Authorities
IFF	Identification Friend or Foe (Secondary surveillance radar transponder)
IR	Infrared
IAI	Israel Aerospace Industries Ltd.
ISR	Intelligence, Surveillance and Reconnaissance (Mission)
LNG	Liquefied Natural Gas
LIDAR	Laser Imaging Detection and Ranging
LOS	Line-of-Sight

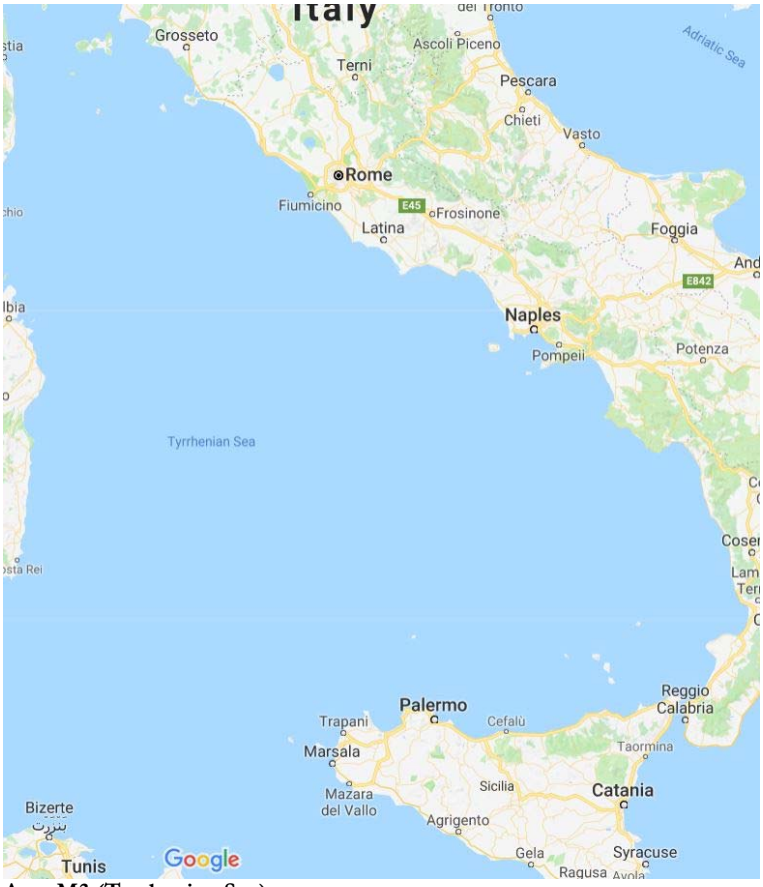
LRIT	Long Range Identification and Tracking
LTA	Lighter Than Air
MAD	Magnetic Anomaly Detector
MALE	Medium Altitude Long Endurance
MAME	Medium Altitude Medium Endurance
MOD	Ministry Of Defence
MR	Medium resolution
MPA	Maritime Patrol Aircraft
MSA	Maritime Surveillance Aircraft
MSP	Maritime Situation Picture
NCC	National Contact Centre
NTR	Nothing To Report
OSD	Oil Spill Detection
OTH	Over The Horizon
RCS	Radar Cross Section
RPAS	Remotely Piloted Aircraft System
SAR	Synthetic Aperture Radar
SatCen	The European Union Satellite Centre
SATCOM	Satellite Communications
SEonSE	Smart Eyes on the Seas
TRM	Transmit/Receive Modules
UCAV	Unmanned Combat Aerial Vehicle
VDS	Vessel Detection Service
VHR	Very high resolution
VMS	Vessel Monitoring System
VTOL	Vertical-Take-Off-and-Landing
VTS	Vessel Traffic Services
WAN	Wide Area Network
WDS	Wake Detection Service

Annex B – Maps of possible regions where RANGER could be used

Area M1 (East of Gibraltar)



Area M2 (Balearic Sea and west od Corsica and Sardinia)

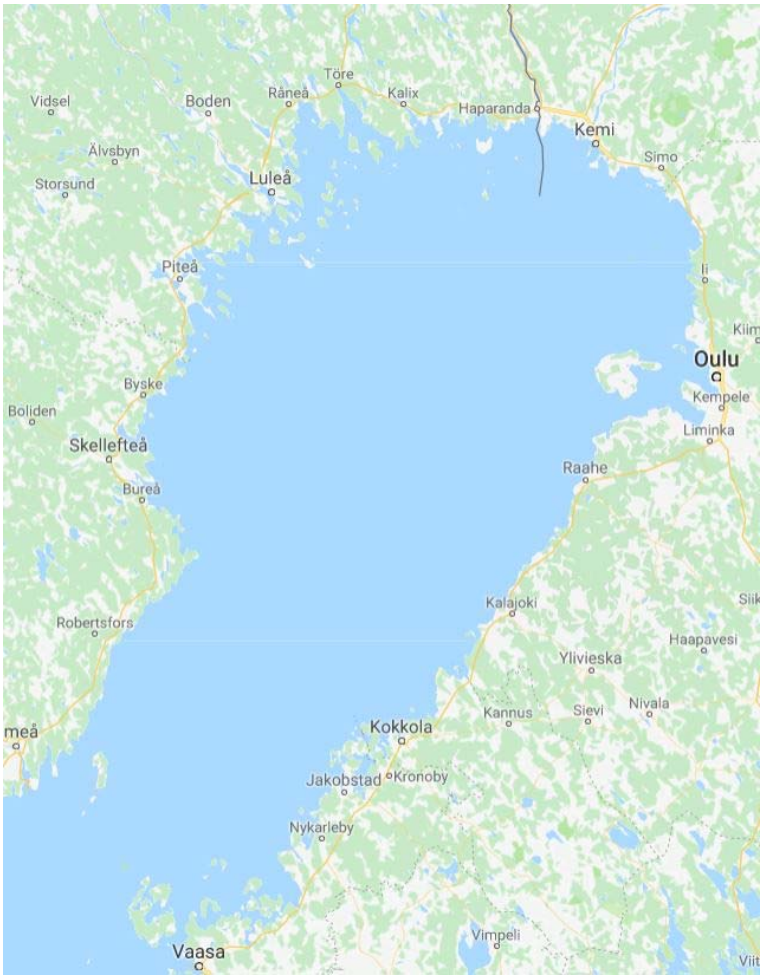


Area M3 (Tyrrhenian Sea)

Area M4 (South Italy-Coast of Libya)

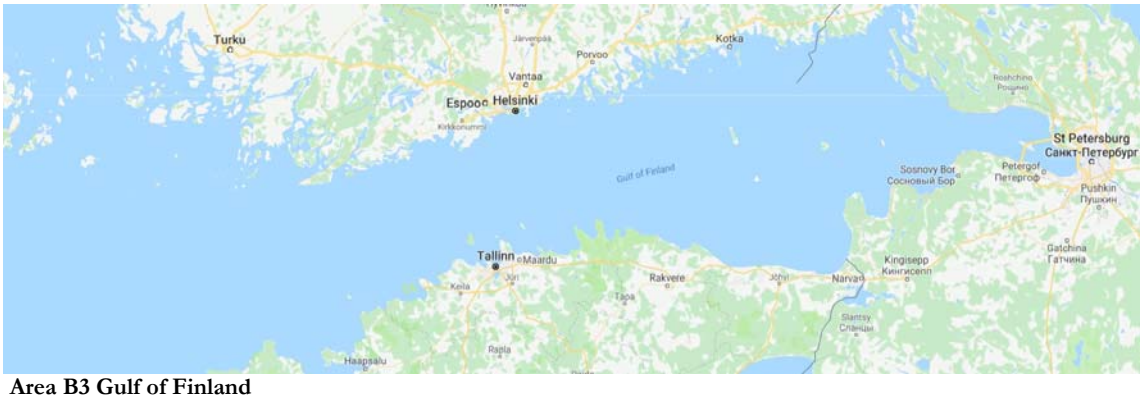
Area M5 (East Mediterranean)

Area M6 (Adriatic Sea)



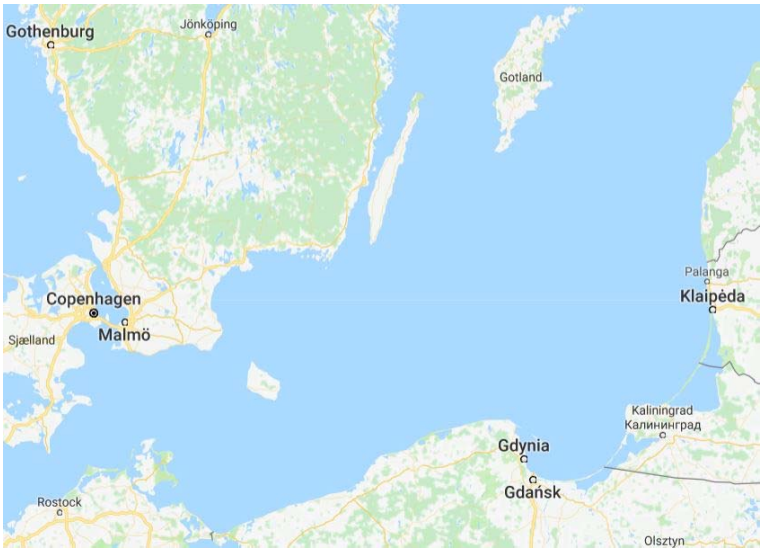
B1 Gulf of Botnia, north

Area B2 (Gulf of Botnia, south

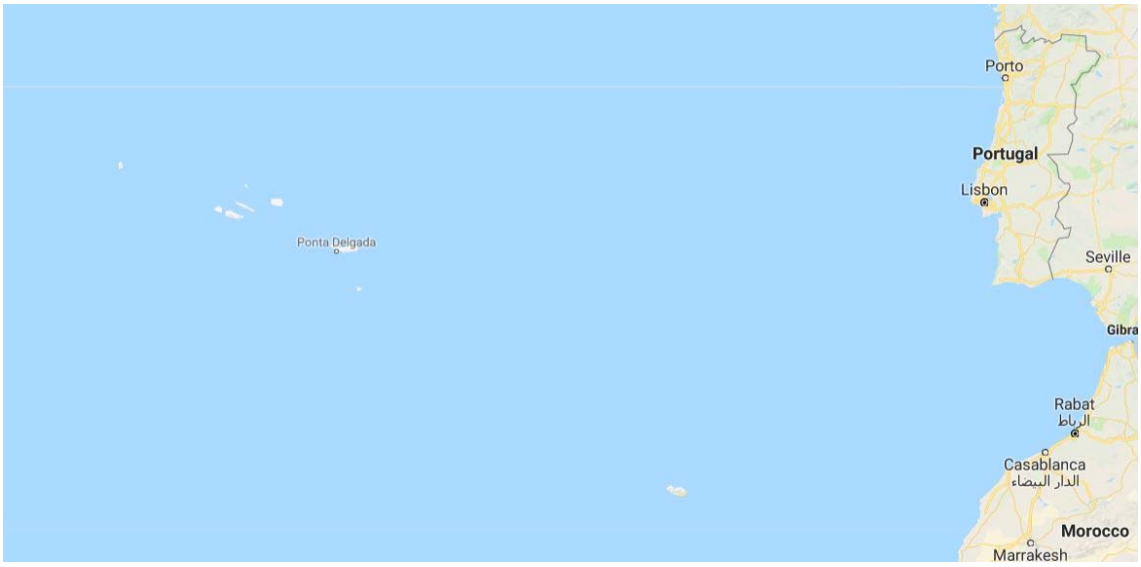


Area B3 Gulf of Finland

Area B4 Baltic Sea, North of Gotland



Area B5 South Baltic Sea



Area A1 Azores

Area A2 Bay of Biscay

Area A3 Canary Islands

Area A4 "DOM-TOM"s

Area A5 North Sea

ANNEX C Comparison of different systems

	Strengths	Weaknesses	Sensors
Maritime patrol aircraft (MPA)	- Long durations over sea and coastal areas - Armed - wide range of sensors - large/dedicated surveillance area	- Operational costs	- Radar for surface ship movement detection - Tracking, infrared cameras - MDA - EO/IR - C2 systems
Maritime surveillance aircraft (MSA)	- Long durations over sea and coastal areas - wide range of sensors	- Operational costs	- Radar for surface ship movement detection - Tracking, infrared cameras - C2 systems
Patrol boat	- Visual identification of interesting targets - capability to under water surveillance	- Operational costs	- Navigational radars - Air surveillance radars (bigger) - under water capability - C2 systems
Satellite imagery	- Improved efficiency - Lower operating costs	- Time difference between satellite crossing and transmission images - Civilian authorities limited access to high-resolution satellite images	- Radar - EO
RPAS	- Useful for many types of missions - Improve search capabilities in large SAR areas - improved durability COMPARED to "manned aircraft" - Faster response times compared to vessels - In adverse weather conditions the associated risk to personnel reduced - can be used as communication relay platforms	- Air space management - limited payload capacity (weight)	- EO/IR - Laser RF - AIS - SAR - Radar - COMINT
HFSWR Radars	- large surveillance area - low personal costs - surface target tracking behind horizon - air and surface surveillance capability	- environmental effects (antennas) - blind spot area - tracking accuracy - need of sensor fusion for identification	
Coastal Radars	- Accuracy - low personal costs	- short surveillance distance	

Strengths and Weaknesses

BAE HFSWR							
Frequency band	**Azimuth coverage**	**Detection range**	**Range accuracy**	**Range resolution**	**Azimuth resolution**	**Detection capabilities**	
HF	_	200 Nm	_	_	_	-	-
						-	-
IAI ELM 2270							
Frequency band	**Azimuth coverage**	**Detection range**	**Range accuracy**	**Range resolution**	**Azimuth resolution**	**Detection capabilities**	
HF	120º	200 Nm	2 km	3 km	array size frequency dependet	1500 tons Ship	low flying aircraft (King Air 200)
						370 km	130 km
Raytheon HFSWR							
Frequency band	**Azimuth coverage**	**Detection range**	**Range accuracy**	**Range resolution**	**Azimuth resolution**	**Detection capabilities**	
HF	_	200 Nm	_	_	_	20m vessel	Class 1 vessel
						173Nm	200 NM
Stradivarius							
Frequency band	**Azimuth coverage**	**Detection range**	**Range accuracy**	**Range resolution**	**Azimuth resolution**	**Detection capabilities**	
HF	_	200 Nm	_	_	_	-	-
						-	-

The OTH radars

IAI ELM2226								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Interoperability**	**Detection capabilities (sea state 3)**		
X	360º	1,5º/3,5º	Over 500 targets	High	EO, CSM/DF, AIS	Rubber boat	Patrol craft	Large ship
						20 km	60 km	Horizon
Hensoldt SBS900								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Interoperability**	**Detection capabilities (sea state 3)**		
X/S	360º	X-band ↕ 14º ↔0,38º S-band ↕14º ↔2,0º	Mount of targets is not mentioned		Mentioned to be easily integrated with both new and existing surveillance and safety systems.	Rubber boat	Patrol craft	Large ship
						Max. instrumented range is mentioned, 48 NM		
Sentinel 400								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Interoperability**	**Detection capabilities (sea state 3)**		

X	360º	X-band ↕ 11º ↔0,35º	over 1000	12-18m/ not mentioned	NTR	Rubber boat	Patrol craft	Large ship
						Max. instrumented range is mentioned up to 96 NM depending on chosen profile		

Terma Scanter 5000								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Interoperability**	**Detection capabilities (sea state 3)**		
X	360º	not mentioned	Mount of targets is not mentioned	High	Mentioned to be easily integrated with both new and existing surveillance and safety systems.	Rubber boat	Patrol craft	Large ship
						Max. instrumented range is mentioned, 96 NM		

The Coastal Radars

EriEye ER								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Interoperability**	**Detection capabilities (sea state 3)**		
S	360º (AESA)	_	_	-	Option for remote operation	Air target	Surface target	
						450 km	100NM	

Leonardos' SeaSpray 7500								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Capabilities**	**Detection capabilities (sea state 3)**		
X	360º (AESA)	-	_	High	AIS integration, Long Range Search, Priority Track, Small target mode, Weather Detection, Search and Rescue Transponder	Rubber boat		Large ship
						Max. instrumented range is mentioned, 320 NM		

AN/APY								
Frequency band	**Azimuth coverage**	**Beam width ↔/↕**	**Automatic detection/ tracking**	**Range accuracy/ resolution**	**Capabilities**	**Detection capabilities (sea state 3)**		
-	360º	-	-		Long-range surface search and target tracking, periscope detection, ship imaging and classification using synthetic aperture radar and inverse synthetic aperture radar.			
						The maritime target detection capability is mentioned to be a radar cross section ranging from 1 to 10,000 square meters at 29 to 200 nautical miles		

The Airborn radars in this deliverable

Annex D– Ethical &Societal Compliance Check –table (of this D8.8 deliverable)

In this table there are summarized the ethical and societal guidelines for the RANGER solution. The table is originally defined in the D3.1. *"SOCIETALLY ACCEPTABLE AND ETHICALLY SUSTAINABLE WAY OF PERFORMING MARITIME SURVEILLANCE"*. Please make this ethical compliance check of each of RANGER deliverable with the help of this table and fill in the needed information in the column "How are the guidelines applied?". Finally attach the table as an annex in the deliverable in case.

Deliverable			**D8.8**
Activity		**Main Responsibility**	**How are the guidelines applied?**
1	**Development of RANGER Code of Conduct and follow-up of the current discussion on maritime surveillance** The initial RANGER Code of Conduct provided in chapter 4 of D3.1 is to be developed and specified more in detail during the RANGER project. Separate versions of the Code of Conduct are needed for RANGER as stand-alone version and for RANGER as part of EUROSUR/CISE.	Project management and ethics committee working.	n/a.
2	**Legal framework follow-up regarding maritime surveillance and its technology** • Especially since RANGER may change the moral division of labor in maritime surveillance (e.g. in SAR where much more information will be available), it may even be a mean to change to the legislation (or how it will be interpreted) • Follow both EU and local legislation and standards (radiation, environment, NATURA2000 etc.) from the design phase of the radars. Be especially aware of the changing legislation.	Each WP in case.	The data protection legislation has been pointed out in chapter 4.4, and the environmental legislation, for example in the country profiles.
3	**Proper understanding of maritime surveillance operations & involvement of end-users** • End-users are to be involved in the project during its whole life span. • End-users should come from various levels of maritime surveillance and from various operations in EU and member states (search and rescue, border control, fisheries control, customs, environment). • Representatives from the third countries from Mediterranean coast site also to be involved in project, as well as various non-government organizations. In addition make it sure that in the research work with the end-users consent forms are always collected and the collection & processing of personal data is avoided	All the work-packages working with end-users.	This has been emphasised e.g. in the chapters describing the various aspects of maritime surveillance and in the country profiles too.
4	**EUROSUR/CISE collaboration in ethics work** Since EUROSUR and CISE probably has already taken into account the critics of forgetting	Project management team	These are taken into consideration in the chapters 2.2 and 3.5.

	humanities in favour of security and new businesses, it is crucial that RANGER's interoperability and compliance with EUROSUR and CISE covers also these ethical issues (not only technology). This includes especially the following issues: • Non-refoulement and the use of RANGER radar to detect vessels on high sea and on the water territories of third counties. • Seeking for the solution how we will deliver the long-distance information RANGER provides also to neighbouring third counties so that they can also enhance their SAR activities. • Seeking for the fair moral division of labour in providing assistance in a situation in which we constantly get distress information outside country's own SAR –regions.	(with the help of ethics committee)	
5	**RANGER business/governance modelling** - RANGER as stand-alone solution, and especially its user processes and business/business model need to be designed carefully, including the user training and selling/procurement strategy which avoids the biased use of RANGER in border control and SAR. - Productizing a feasibility study and societal impact assessment about RANGER and its use in the proposed area before the implementation as part of the "RANGER package", including needed activities to eliminate undesirable consequences beforehand. - When selling RANGER as stand-alone solution, follow up of the consequences of the use of RANGER technology is needed to provide as part of the "RANGER service package". - Selling RANGER only for the use of municipalities or other authorized bodies (>the avoidance of the misuse and dual-use) - Licensing	WP 8	These issues are highlighted when introducing the different components as well as the business ecosystem..
6	**Design of the RANGER technology/Data management and security** - "Privacy by design" and other requirements (anonymizing etc.) defined in the coming new Data Protection legislation (Act + Directive). - Specific Data security standards are to be followed - User logs as part of the system. - Check and balance approach - Limit the access to the RANGER data only to relevant authorities (access rights, ranger business modelling) - Rules & regulation on the use of data	Technical partners	n/a
7	**Design of the RANGER technology/ The modifications of the user interface according**	Ethics committee and	The need for RANGER solutions is emphasised when pondering the

	the users background/maritime surveillance aspect - SAR criterion, human rights and other ethical guidelines should be taken into account when developing the RADAR technology, its processes and business model. - The language and terminology of the user interface should serve each aspect of maritime surveillance (by taking into account the status of the user logged in)	technical partners	maritime surveillance market, since usually market exists because of a need.
8	**Design of the RANGER technology/Physical design of the radar antennas** Hire industrial designer etc. to create beautiful antennas and radars.	WP 4	n/a
9	**Continuous societal impact assessment of RANGER during the project** • Joint societal impact assessment with all the work packages will be done in the mid and end of the project under the work of ethics committee and documented in D3.2. This concern especially the Mediterranean area where the system is to be piloted. Also expertise from other areas than maritime surveillance are needed in order to figure out the impacts on society (e.g. irregular immigration) • In addition each wp is expected to conduct SIA among their own stakeholders	Ethics committee and each work-package	n/a
10	**Communication and dissemination** - Good PR and information with local communities. Make communities understand both the benefits are disadvantages - It is necessary in the RANGER dissemination and communication use the terms "irregular" "asylum" and "illegal" in a logical and informative way.	WP 8	n/a
11	**Guidelines for the installation and use of the system** - Rules & regulation on the use of data. Training as part of the RADAR implementation on necessary also from this point of view. - Consider environmental studies when installing the antenna, and be in contact with archaeological experts before installing the system. Have agreements from local/national authorities to install and use HF waves - The installation of the radars in a places which are already occupied for same kind of activities (e.g. military bases) - Choose the right location for the radar that doesn't cause problems to the nature, archaeological sites, tourism. To mitigate human exposure in radiation, the OTH radars can be located in unpopulated areas. Further minimize the power levels by improving the directivity of the radar.	WP 7 + trials	n/a

	- Safety instructions are also needed for installing radars and doing maintenance work.		
12	**Follow-up of the implementation of these guidelines** Work Packages (WPs) and their deliverables (in which an ethical and societal compliance check is to be added as an annex of each deliverable).	Each WP	done