Closing the Robotics Market Gap through the Robotics for Inspection and Maintenance Network

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Edited by

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THE CURRENT STATE OF AFFAIRS

CHAPTER 1

INTRODUCTION

CHRISTOPHE LEROUX

1.1. EU infrastructure

"Infrastructure consists of the basic assets and structures that support economic activity" to quote a report from EPRS[1] a think tank of the European Parliament. The report further adds that, "Investment in such assets is ***markedly different from other types of capital expenditure****, due to the* ***heavy involvement of the public sector*** *and the* ***significant positive spill-over*** *that it generates throughout the economy".*

Investment in infrastructure in the key sectors of energy production and distribution, transport, water supply and sanitation, and telecommunications are fundamental to European society, which needs new technologies and modernized infrastructures to cope with population growth and demographic changes. The European Investment Bank (EIB) estimates indicate that achieving the targets of the EU digital agenda would demand additional investment of approximately €55 billion per annum.

According to the EPRS study[1], investment in infrastructure has been declining since 2009 in Europe. EIB estimated that investment needs for energy, transport, water supply and sanitation, and telecoms are as much as €688 billion per year. For water and sanitation, and telecoms, the needs reach €160 billion and €138 billion respectively. In addition, EIB estimates current investment in social infrastructure (health, education and social housing) at €142 billion per year[2] in the EU.

The investment needed for the inspection, maintenance and repair of infrastructure activities is equiparable to those required for the construction of the infrastructure at any given time. Experiences with roads show that if maintenance is neglected over a period of 3 years, the necessary repairs to these roads will probably cost 3 to 6 times more than relevant maintenance[3]. A Chicago Metropolitan Planning Council report[4] indicated that maintenance accounts for the bulk of its resources, nearly 90% of the more than $2 billion the state spends each year on highways. Poor infrastructure maintenance can also reveal or cause fears and changes in behaviour – for example, a J.D. Power survey[5] shows that one quarter of Americans claim never to drink tap water due to the bad smell and fears about water safety. In the USA, local and state governments collectively spend in excess of $100 billion per year on the construction, maintenance, and repair of roads, bridges, and ancillary components (e.g., FHWA 2008, 2019)[6]. Different analyses of the importance of inspection and

1 Zachariadis Ioannis Agamemnon, Investment in infrastructure in the EU Gaps, challenges, and opportunities, October 2018. EPRS | European Parliamentary Research Service
https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/628245/EPRS_BRI(2018)628245_EN.pdf
2 EIB, Investment Report 2017/2018: From Recovery to Sustainable Growth, November 2017.
3 Burningham, Sally; Stankevich, Natalya. 2005. « *Why Road Maintenance is Important and How to Get it Done* ». Transport Notes Series; No. TRN 4. World Bank, Washington, DC. © World Bank.
https://openknowledge.worldbank.org/handle/10986/11779
4 Peter Skosey Chicago Metropolitan Planning Council, "*Fix it first: The importance of infrastructure maintenance »,* 2012, https://www.metroplanning.org/news/6578/Fix-it-first-The-importance-of-infrastructure-maintenance
5 J.D. Power Finds, *Results of poor infrastructure maintenance reveals fears and changes in behaviour*, May 2020, https://www.jdpower.com/business/press-releases/2020-us-water-utility-residential-customer-satisfaction-study
6 Mc Donough Ryan P., Yan Claire J., *Maintaining Maintenance: The Real Effects of Financial Reporting for Infrastructure,* July 2021,
https://www.brookings.edu/wp-content/uploads/2021/05/McDonough-Yan-Paper_July2021.pdf

maintenance can be found in various reports[7]. Figure 1 illustrates the links between the cost of maintenance and the amount of maintenance.

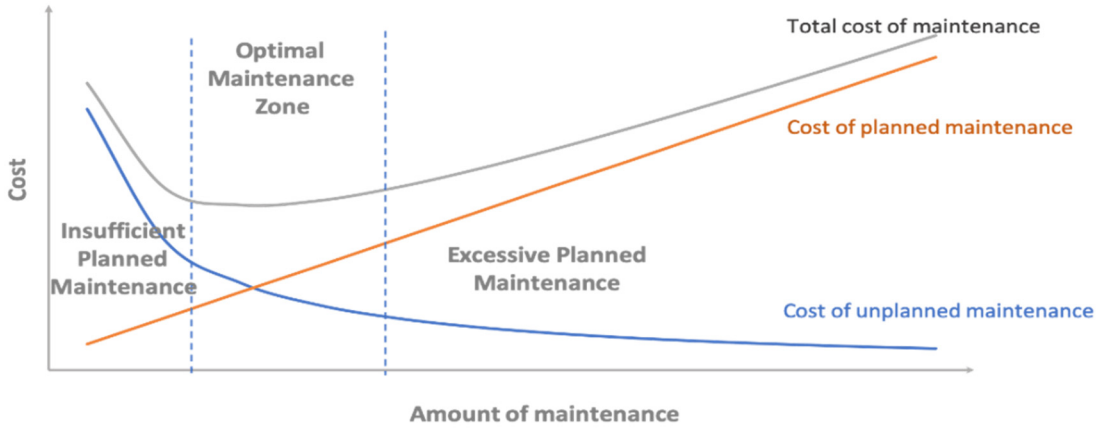

Figure 1: Amount of maintenance[8]

This book presents the efforts of the RIMA (Robotics for Inspection and Maintenance) European H2020 project9 to stimulate innovation in the use of robotics technologies for the inspection, maintenance and repair of infrastructure. The aim of RIMA was to create an instrument—a network of Digital Innovation Hubs (DIHs) on inspection and maintenance (I&M) robotics named the RIMA Network—and to demonstrate the usefulness of this network in funding and mentoring small and medium-sized companies (SMEs) that are developing new solutions for the inspection and maintenance of infrastructure in different sectors.

We present a summary of the study we conducted to analyse the market potential of robot technologies that inspect and maintain infrastructure. The results of this study were used to frame the project. We present the concept of DIHs and the way that RIMA activities and services were organized based on the principle of supporting SMEs willing to create innovative solutions. We also present details of the competitive cascade funding (FSTP) instrument that was used to support SMEs financially, technically and in the development of their product and their business. The SMEs that won this funding ran experiments mentored by RIMA partners who also provided services. We introduce the RIMA Alliance that was created out of the RIMA Network in order to promote the sustainability of our network and engage further organizations interested in supporting innovation in robotics for I&M. This book finishes by providing our recommendations based on lessons learned throughout our RIMA experience.

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Burningham, Sally; Stankevich, Natalya. 2005. « Why Road Maintenance is Important and How to Get it Done ». Transport Notes Series; No. TRN 4. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/11779 License: CC BY 3.0 IGO

7 Babych Yasya, Leruth Luc, *For a Better Budget Management of Infrastructure Investments*, Freenetwork, February 2021, https://freepolicybriefs.org/wp-content/uploads/2021/04/freepolicybriefs20210419.pdf

8 Thi Hoai Le, A., N. Domingo, E. Rasheed, and K. Park, "Building Maintenance Cost Planning and Estimating: A Literature Review," 34th Annual ARCOM Conference, Belfast, UK (2019).

9 Project funding page: https://cordis.europa.eu/project/id/824990

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1.2. The field of inspection and maintenance

Inspection and maintenance (I&M) represents a large economic activity spanning across multiple sectors such as energy production and distribution, water supply, transport, and communication. There is massive potential for robotic applications, to increase productivity, reduce costs and improve safety. The total market size of robotics is however still negligible in relation to the overall market size.

Currently the EU is a global leader in this rapidly growing field with more than half of all manufacturers of I&M robots based in Europe. The EU hosts over 50% of I&M robotics offer but there is a bottleneck connecting these technologies to the market and applications with high potential.

RIMA was a 4-year project that aimed to tackle this bottleneck by establishing a network of DIHs and industry / industrial associations (the “RIMA Network”) to support the uptake of robotics – and help SMEs to develop novel I&M solutions for different sectors. The support from sectorial associations was essential for making a bridge with relevant industrial actors in the value chain.

Challenges included: reinforcing network connections, providing education and training about I&M using robotics, and connecting the value chain—researchers, technology providers, service providers, asset owners, asset operators, and investors – in order to accelerate economic growth in the field.

RIMA gathered leading research organizations from across Europe to create a network, each research organization supports a regional DIH which has activities aligned with regional policies and industrial sectors. The RIMA Network was built in close cooperation with the SPRINT robotics association, a project partner, in order to ensure the sustainability of the network.

RIMA support to SMEs is organized using a bottom-up approach driven by end-user needs and presented in the form of a set of services designed to facilitate understanding and dialogue across all relevant actors in the value chain.

More than 2/3 of RIMA's budget was used to support SMEs financially and mentor SME experiments

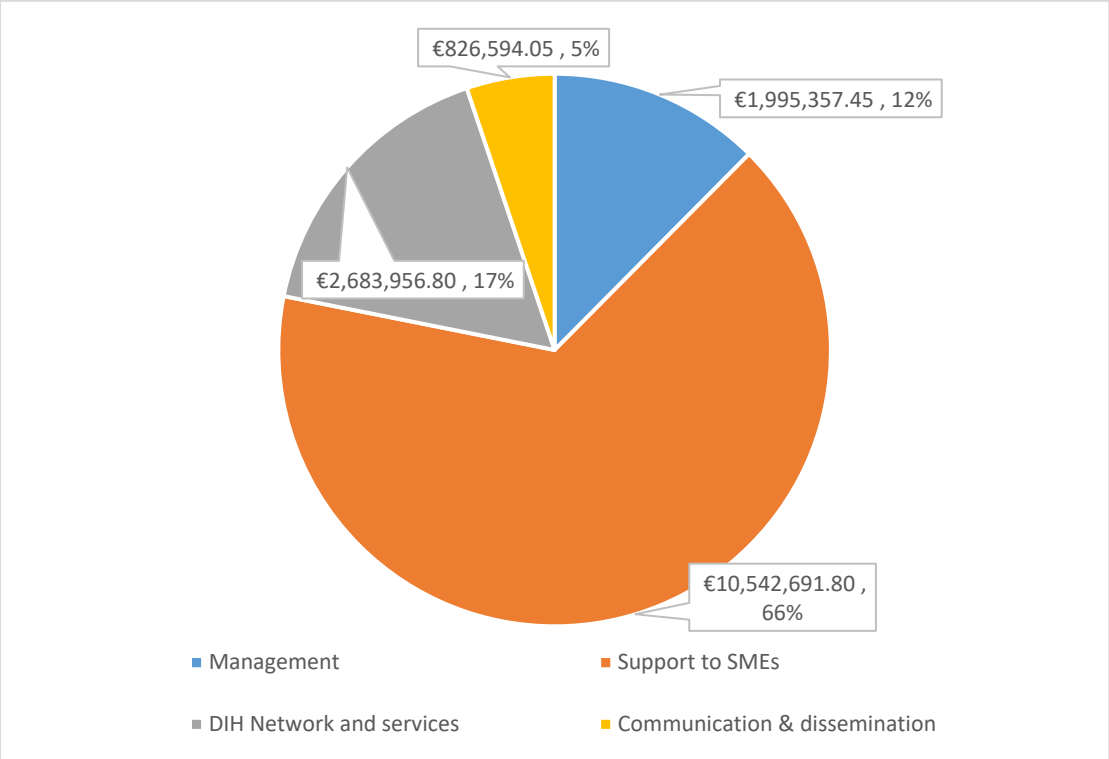

Figure 2: Budget share per activity in RIMA

The objectives of RIMA Network were

- increased competitiveness of EU I&M robotics,
- economic added value by increased productivity and availability of the critical infrastructure,
- social and environmental impact through improved safety and reduced emission of hazardous substances, and
- the constitution of a sustainable and scalable (open to new members) DIH network aligned with industrial and European policies and ambitions.

SECTORS COVERED

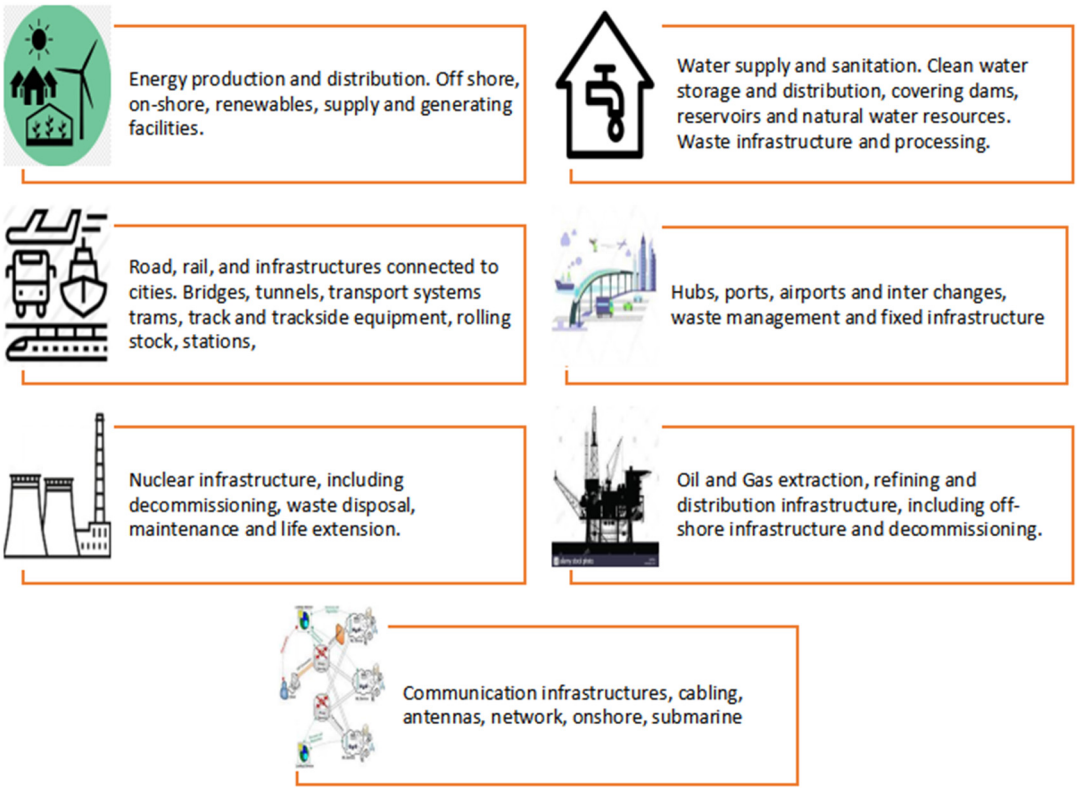

Figure 3: Sectors covered by RIMA Network members

CHAPTER 2

THE RIMA NETWORK

BEGOÑA ARRUE CHIQUINQUIRA AND JOSÉ LUIS ANDRADE PINEDA

2.1. RIMA Network core features

RIMA COMMUNITY TOOL

RIMA Network seeks to connect and inspire key stakeholders in I&M robotics and to accelerate innovation and uptake of robotics. The RIMA Network Community is a place to collaborate, share information about I&M robotics and keep up-to-date about RIMA activities.

In this way, the RIMA Network aspires to bring together technology providers, service providers, asset owners and operators, DIHs, and other facilitators, to join forces and competences in accelerating robotics deployment in I&M.

Join us to be part of this global community to collaborate, share knowledge, and participate in RIMA events and activities!

FUNDING

RIMA provided financial and technical support for 50 cross-border experiments involving European SMEs through 2 Open Calls (2019 / 2020) with a total funding of 8.1M€.

Successful candidates received equity-free funding for technology transfer and development in I&M robot applications.

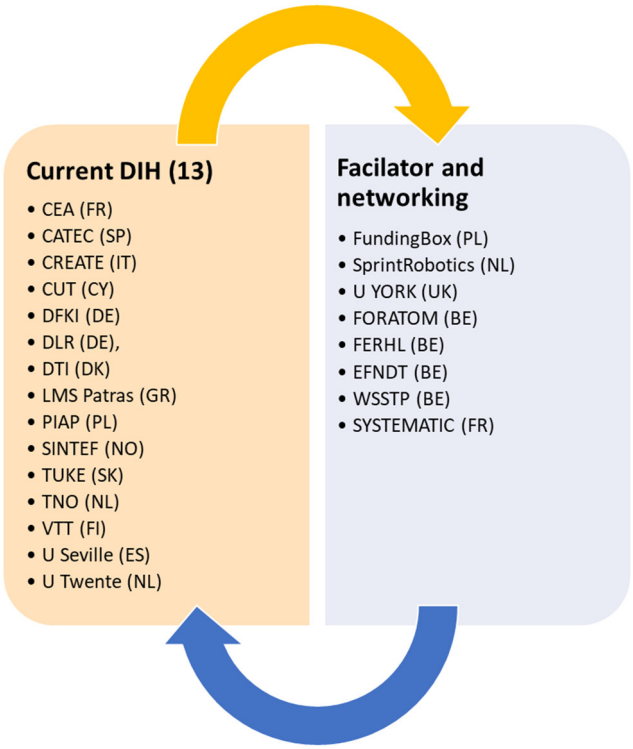

Figure 4: The RIMA Network at project start

NETWORK

RIMA brought DIHs and other facilitators together into a common network that allows them to join forces and competences in promoting I&M robotics. The facilitator organisations have the connections and network to reach a broad set of industries in their domains of expertise. The initial RIMA Network comprised 13 DIHs and 8 facilitator organisations and is still open to new members through the RIMA Alliance framework.

DIHs offer key acceleration services for companies. These DIHs include organizations involved in research and innovation activities, and they offer expertise in robot technologies, sensors, and other equipment and services applicable for I&M operations.

TRAINING

The RIMA Network provides skills and tools to implement the latest methods in knowledge transfer between academia and industry.

The RIMA training framework aims to increase digital skills and knowledge of robotics, especially within the I&M domain, amongst a wide range of people – from students starting out on their career path, through the current workforce who need to retrain, managers who need to understand the importance and effect of digitisation, and start-up technology developers that need concrete information and support for getting their upcoming technology to market.

Figure 5: Examples of RIMA Network services

2.2. The concept of DIHs

Digital Innovation Hubs are one-stop-shops that help companies become more competitive with regard to their business/production processes, products or services using robotics and other digital technologies. DIHs provide access to technical expertise and experimental facilities, so that companies can "test before invest". They also provide innovation services—such as financial advice, training and skills development—that are needed for a successful digital transformation. Key environmental issues are also considered, in particular regarding energy consumption and low carbon emissions. As proximity is considered crucial, they act as a regional first point of contact, a doorway for local organisations to reach through, and thereby strengthen the local innovation ecosystem. A DIH is a regional cooperation between organisations such as research and technology organisations (RTOs), universities, industrial associations, incubators/accelerators, chambers of commerce, regional development agencies and vocational training institutes and can also have strong connections with service providers located outside their region, supporting local companies by providing access to services and facilities that are not available locally.

Each DIH acts as the epicentre of a local/regional or even national digital innovation ecosystem able to provide access to services, facilities, and expertise belonging to a wide range of organisations. The aim is to ensure that the individual customers (mostly from smaller companies or the public sector) get the services they need and that regional market segments get access to innovative, scalable solutions.

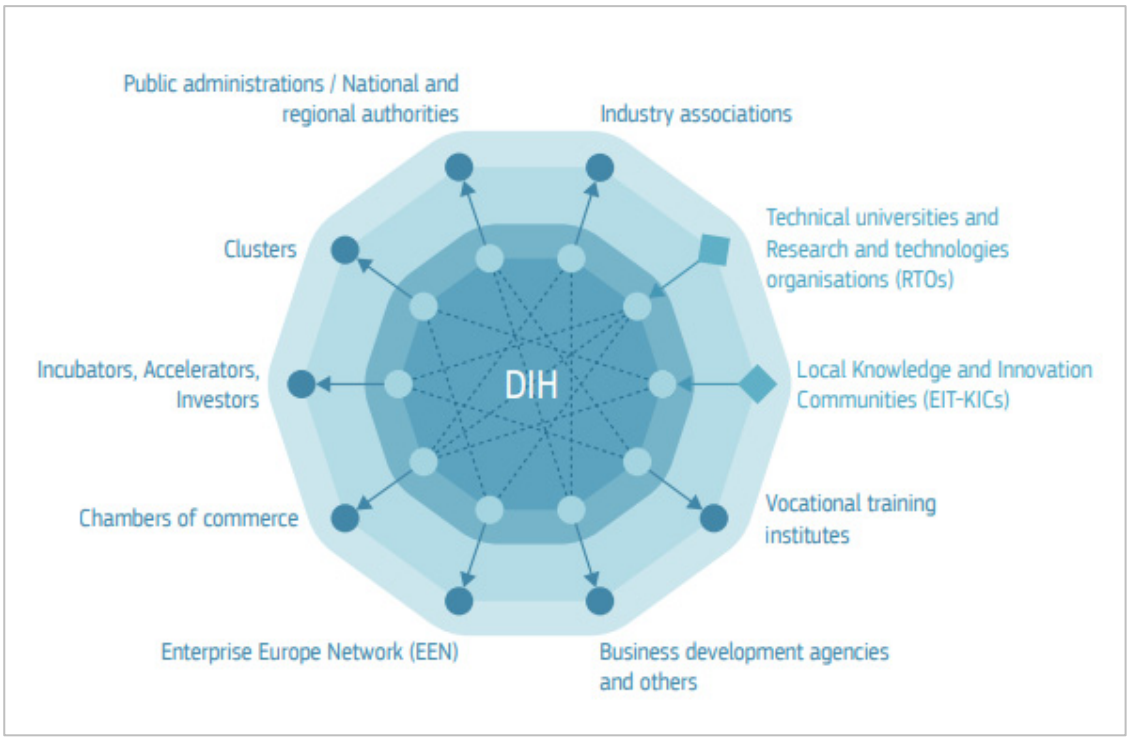

Figure 6: DIH concept

To reach that goal, DIHs cooperate with each other at regional, national and/or European level. Customers can approach different DIHs depending on their technological and sectorial specifications. Any organisation interested in DIH services can choose the DIH that best matches their criteria (geography, sector, technology, type of service, etc.) via an interactive tool that helps navigate the network of DIHs available in Europe.

The RIMA Network maximises synergies among its members and contributes to promoting a joint approach and branding, making possible a bigger recognition of the initiative outside its ecosystem. Technology supplier and developer involvement means that RIMA has access to a wide range of expertise and facilities. Our ability to reach end users increases the chances of engaging SMEs and other potential customers. RIMA activities can also be seen as a way to raise awareness about Europe's "Digitising European Industry" strategy and the role of the DIHs within it. In addition, RIMA Network members have been able to achieve the realisation of research and innovation objectives linked to the transformation of robotics deployment in infrastructure companies and the public sector by addressing these user's specific and general challenges.

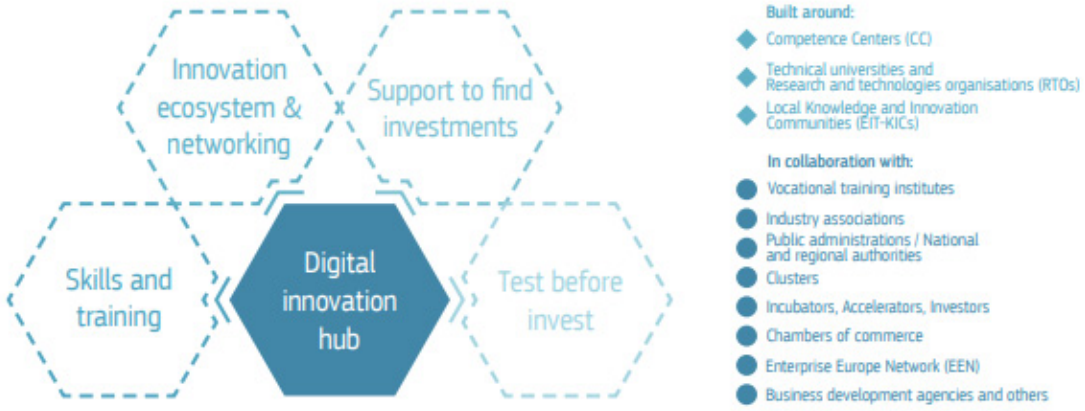

Figure 7: DIHs key information

The main services offered by the RIMA DIHs are:

Access to innovation and leading-edge technologies and applications expertise: in manipulation, teleoperation, navigation, human robot collaboration, supervision, control, mechatronics, sensing, perception, non-destructive testing, AI; for standard and non-standard robots e.g. snake robots, autonomous and semi-autonomous drones: aerial, terrestrial, subsea or underwater, and more.

Funding opportunities and technology acceleration programmes: the Open Calls of RIMA Network Innovation Actions funded experiments and "test before invest" activities to understand the new opportunities available and return on investments, also demonstration facilities and piloting.

Strengthening the relationships of SMEs with DIHs and other relevant actors: through the online community, engagement activities and RIMA training activities.

Skills and training to make the most of digital innovations: "train-the-trainer" programmes, bootcamps, traineeships, exchange of curricula and training material, the RIMA training catalogue.

Support in finding investment and other close-to-market opportunities: supported access to financial institutions and investors in order to access follow-up finance to bring the results of testing and experimentation to the next phase, also access to incubation and acceleration programmes.

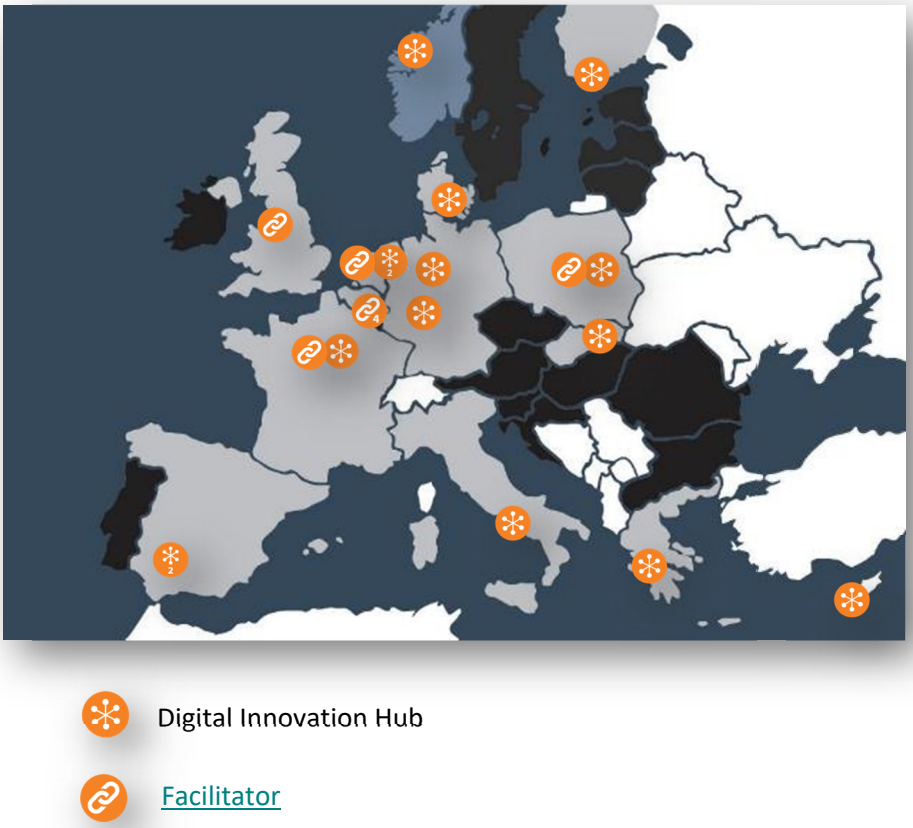

Figure 8: Map of RIMA Network members 2019-2023

To find a full list of European DIHs, not just those in RIMA, see here: https://european-digital-innovation-hubs.ec.europa.eu/edih-catalogue

For a fuller description of the RIMA Network DIHs, please go to section 6.

CHAPTER 3

MARKET BACKGROUND

KRZYSZTOF LIPIEC AND JAKUB GŁÓWKA

3.1. Estimate of the market

The market analysis conducted in early 2021 aimed to frame the innovation activities for Inspection and Maintenance of Infrastructure robotics. The Market Study Unit from CEA conducted this analysis with the support of other RIMA partners.

This section provides key elements contextualizing the positioning of the RIMA DIHs. These elements are available on the community portal. The complete market study is available for free through the SPRINT robotics association1 as an offer from the network.

In the following subsections, we start with a description of the approach chosen; we then give some figures and some general characteristics of the market. We conclude by presenting the implications of this market research for the value proposition of RIMA's DIHs. This value proposition is transferable to other DIH networks.

THE APPROACH

We had two options for this market study: top down or bottom up. These two options are presented in Figure 9 with some comments about the advantages of each of them.

1 https://community.rimanetwork.eu/7423/rimad34v61docx

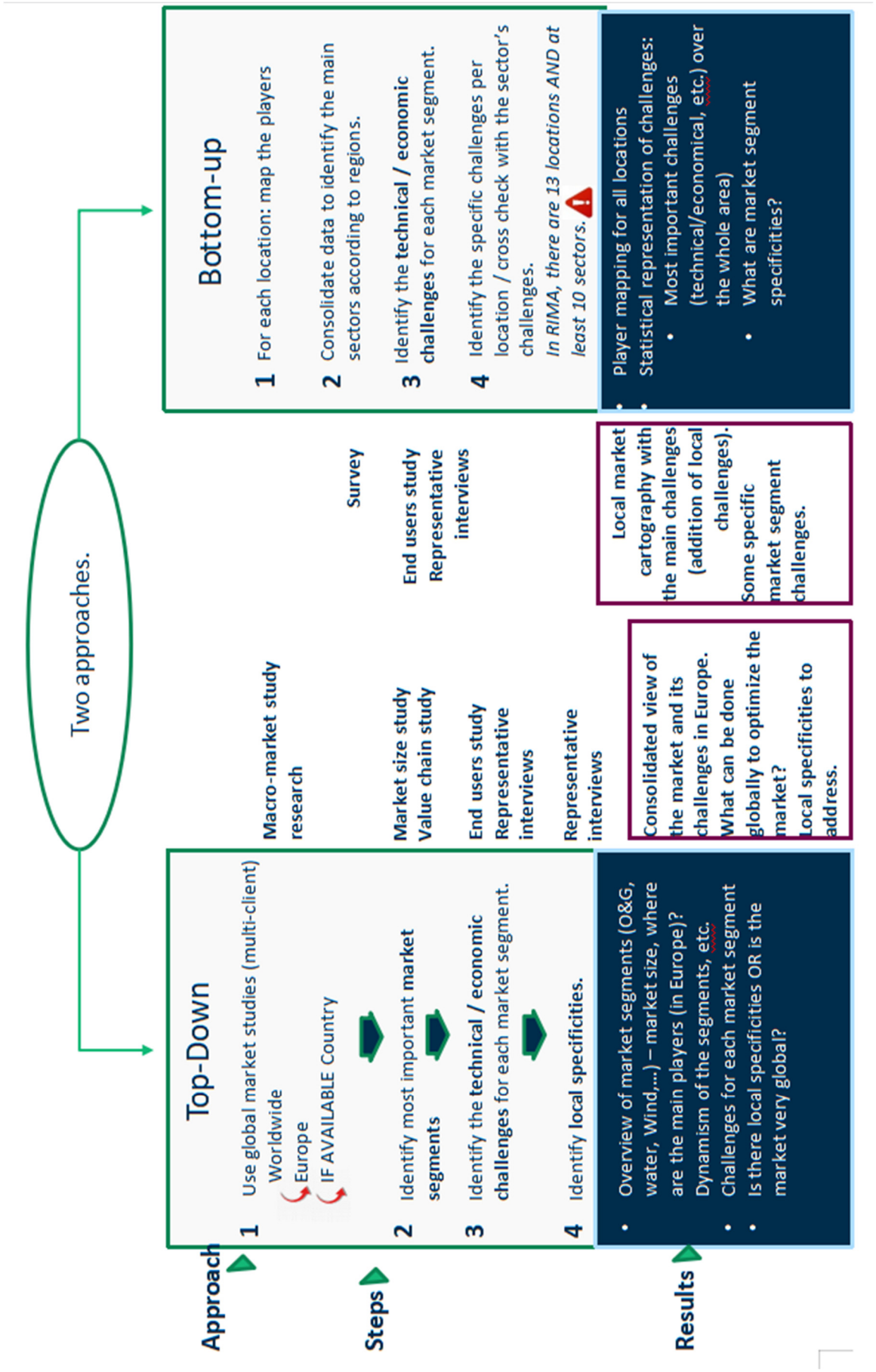

Figure 9: Market study: two possible approaches

The market study started with an investigation of the material already available. No relevant market data was available in the Public Private Partnership SPARC archives, at the EC or via the euRobotics aisbl, and the market information available from the RIMA partners was partial and not uniform. We therefore decided to collect new and unified data. We chose to follow a global approach for the market study for the following reasons.

Added value for RIMA DIHs

Regional DIHs already have good knowledge of their local ecosystem as shown by the activities each DIH has carried out in the past regarding robotics for inspection and maintenance of infrastructure. RIMA partners felt that a global approach would be beneficial for the development of their service provision. The thirteen RIMA DIHs are situated in twelve countries in Europe. Obtaining specific information on markets in regions where no RIMA partner is located would have been very uncertain – there were even difficulties in obtaining reliable information from the regions and countries where RIMA partners were located. Consortium partners also thought that a global market study would help them share a common vision and be more generally relevant.

The multi-sectorial aspect of inspection and maintenance

The RIMA network covers many sectors. Conducting a multi-sectorial market study in as many regions as there are RIMA Network members would have been a considerable effort, and the results would have been difficult to consolidate at European and international scales. Partners' efforts to obtain local market information revealed the challenges of collecting multi-sectorial data and strongly suggested that this approach would not be successful.

Multi-national aspect of some sectors

Some sectors covered by RIMA like oil and gas, nuclear, and renewable energy (wind) are supported by multinationals which are looking for global solutions applicable in all countries over the planet.

Expectations from RIMA customers

All SMEs which interact with the RIMA network require global market data to develop fully.

MARKET ESTIMATES FOR I&M ROBOTICS TECHNOLOGIES

This section attempts to estimate the overal number of potential companies with which RIMA members could interact. These are mostly end-user companies with an interest in using robot technologies to support innovation in infrastructure I&M. The figures below are indicative and will be refined later.

Case of flying drones

The RIMA market study found that around 3,800 companies in France[2] were operating professional drones weighing over 800 g in different sectors in 2019. Europe as a whole is estimated to contain approximately five times the French figure, so extrapolation to Europe gives approximately 3,800*5 = 19,000 companies operating professional drones over 800 g in Europe in different application domains.

The same study indicates that in 2019 the global market for professional services using flying drones for infrastructure I&M involved about 5% of the general market for drones[3]. Making the simplifying assumption that this also corresponds to the number of companies concerned by these subjects, there

2 "Aviation Civile" publication from the DGAC – French Civil aviation authority; 01/2020 DGAC
3 The 2018 Drone Market Sector Report by Skylogic Research LLC

would therefore be 950 companies in Europe operating professional drones in the infrastructure I&M market.

Robots other than drones

The market study also indicates that the I&M market for robots other than drones is at least three times larger than that for drones. Let us assume that the number of companies is proportional to the market, there would therefore be approximately 950*3 = 2,850 companies in Europe operating robots other than drones in the infrastructure I&M market[4].

An overall estimate

Therefore there would be about 2,850 + 950 = 3,800 companies of all sizes operating robots (including drones) for infrastructure I&M.

These estimates are from the first results of the market study. It would not be surprising if in reality there were considerably fewer or, more likely, considerably more companies involved – and the numbers are growing. Reasoning around a range of 1,000 to 10,000 companies offering robotic I&M services (air, sea, submarine, land) would seem be a sound estimate.

Extrapolating the number of "customers" seems riskier. Assuming that each of these companies work for three to five clients maximum, that would mean that there could be approximately 3,000 to 50,000 customers benefiting from the use of I&M robots in Europe.

This estimate should be revisited and consolidated later.

MARKET CHARACTERISTICS

The global inspection and maintenance robotics market in 2020 was worth $4,9bn. Its growth is +19 % CAGR[5].

The I&M robotics market is highly fragmented, both at European and global level. The market is composed of a myriad of companies (around 3,500 as we just mentioned) mostly small and very technical, each offering a very specific robotic platform.

Interviews with stakeholders from different sectors show that robotic companies have to develop a different robot solution for almost every client (the complete market study is provided in a document accessible through the RIMA Network). Figure 10 illustrates a Zion meta study that examined several market investigations[6]. It illustrates market segmentation: the major players for each segment are small and specialist companies that are present in only in one segment. Only a few players appear in several segments.

Although we have seen a few mergers and acquisitions, most robotic companies remain very small, not able to grow because of this lack of market organization. Robotics companies are often incorporated by Non-Destructive Testing (NDT) or inspection services companies (ex: Fugro has completed the acquisition of General Robotics Limited (GRL), Eddyfi Technologies acquired NDT Robotics Leader Inuktun).

4 Professional Service Robots Market Size, Share & Trends Analysis Report By Application (Logistics, Healthcare, Customer Service, Field Robots), By Region, And Segment Forecasts, 2020 - 2027 ; Grandview Research 2017
5 https://www.technavio.com/report/inspection-robots-market-industry-analysis
6 Research and markets April 2018, Zion Market Research - April 2018, Transparency Market Research 2018,

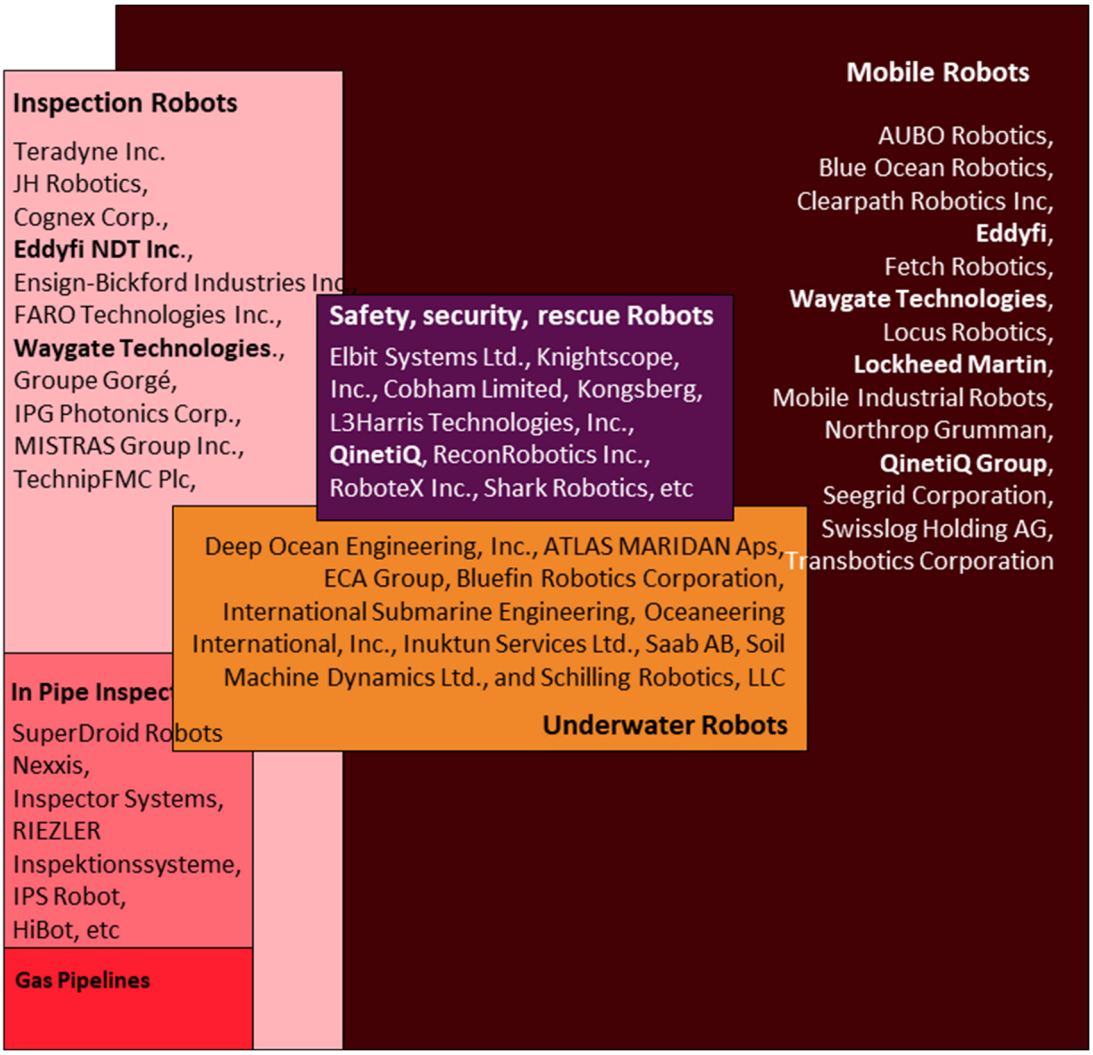

Figure 10: Major players per robotic segment

If we refer to the Technavio market study[13], as a sample a non-exhaustive list of their variety, some of the major players for inspection robots worldwide are depicted in the following picture:

	PERS	REVENUE (2020)	Activity	
EDDYFI	475	130M€	NDT Acquisition of many **pipeline inspection** companies	
TERADYNE (owns Universal Robots)	5 500	$2,1bn	Automatic test equipment	
IPG Photonics Corporation	5 960	$1,4bn (2017)	High-power fiber lasers and amplifiers (inspection, welding, etc)	
Waygate Technologies (a BAKER HUGHES Cie)	300	$38M	Industrial inspection solutions - NDT. Develops mobile inspection robots for **large-scale facilities** in the field of power generation and industrial processing	
JH Robotics	30	$6M	Collaborative robots / automated inspection is a small part of their business	
Cognex Corp.	2000	$725M	Machine vision products / robotic is a small part of their business	
Faro Technologies	1800	$385M	High-precision 3D capture, measurement and analysis across a variety of industries (manufacturing, construction, engineering and public safety)	
Groupe Gorgé	1800	€270M	Safety: Drone and systems, 3D printing and engg	
Nexxis	24	$4M	NDT and Manufacturing automation	

Figure 11: The size of the major companies providing digital I&M technologies, from 13

These example companies are mostly small and most of them are North American. However, field interviews led to an observation that those high-tech companies remain very small. This can be surprising with respect to the high expectations towards robotic and potential of applications. This rises further questions to take into account when approaching these companies, such as: Maybe they are very automated? So employee numbers are expected to be low?

The global market growth for infrastructure I&M robotics, expressed as CAGR, is expected to be around 19%[7]. This is rather good growth with respect to global market growth.

Major market issues

Feedback from robot companies indicates that one of the major issues is the effort needed to develop proof of concepts (PoC) and run tests. Indeed, technology providers have almost to tailor their robots for each of their customers. It is a major trend in this market. Time is dedicated, in particular, to: tuning their robot, finding and/or adjusting testing infrastructures, preparing PoCs, running tests, quantifying and qualifying the results. This work prevents those companies from growing —it is not so much a question of cash, but a matter of resource allocation. Small companies cannot develop several platforms in parallel, therefore they cannot expand their market.

DIH AND RIMA NETWORK VALUE PROPOSITION

The market study conducted during the RIMA project details the challenges that can be addressed by the RIMA network. We focus on two of them.

7 Inspection Robots Market 2020-2024 | Advantages of Robotic Inspection Over Manual Inspection to Boost Growth | Technavio