RE4DY

MANUFACTURING DATA NETWORKS

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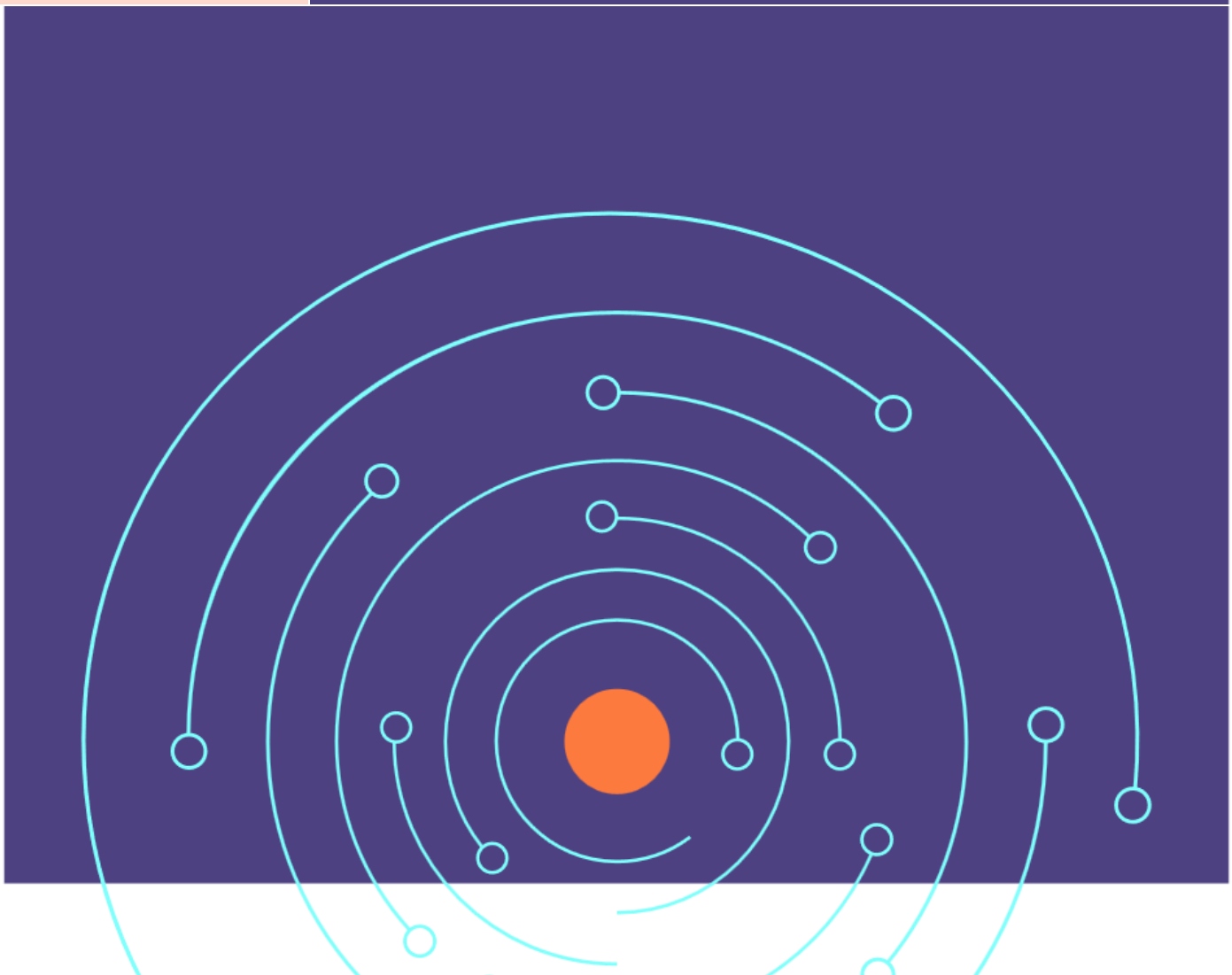

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Project Partners

Number	Participant organisation name	Acronym
1	ASOCIACIÓN DE EMPRESAS TECNOLÓGICAS INNOVALIA	INNO
2	CHALMERS TEKNISKA HOGSKOLA AB	Chalmers
3	INTERNATIONAL DATA SPACES EV	IDSA
4	VOLKSWAGEN AUTOEUROPA, LDA	VWAE
5	ASSECO CEIT AS	CEIT
6	UNINOVA-INSTITUTO DE DESENVOLVIMENTO DE NOVAS TECNOLOGIAS-ASSOSIACAO	UNI
7	FILL GESELLSCHAFT MBH	FILL
8	AVL LIST GMBH	AVL
9	VISUAL COMPONENTS OY	VIS
10	UNIVERSIDAD MIGUEL HERNANDEZ DE ELCHE	UMH
11	ATLANTIS ENGINEERING AE	ATLANTIS
12	DATAPIXEL SL	DATA
13	CORE KENTRO KAINOTOMIAS AMKE	CORE
14	UNIVERSITETE I OSLO	UiO
15	GE AVIO	AVIO
16	ENGINEERING-INGENIERIA INFORMATICA SPA	ENG
17	POLITECNICO DI MILANO	POLIMI
18	ATOS IT SOLUTIONS AND SERVICES IBERIA SL	AtoS
18.1	ATOS SPAIN SA	AtoS-ES
19	KATHOLIEKE UNIVERSITEIT LEUVEN	KU
20	NETCOMPANY-INTRASOFT SA	INTRA
21	NOVA ID FCT - ASSOCIACAO PARA A INOVACAO E DESENVOLVIMENTO DA FCT	NOVA
22	INDUSTRY COMMONS FOUNDATION (INSAMLINGSSTIFTELSE)	ICF
23	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	CERTH
24	GRUPO S 21SEC GESTION SA	S21SEC
25	UNIVERSITAT POLITECNICA DE VALENCIA	UPV
26	CONSIGLIO NAZIONALE DELLE RICERCHE	CNR
27	SOCIEDAD ANDALUZA PARA EL DESARROLLO DE LAS TELECOMUNICACIONES SA	SANDETEL
28	SWITZERLAND INNOVATION PARK BIEL/BIENNE AG	SSF
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30	FRAISA SA	Fraisa SA
31	SIEMENS SCHWEIZ AG	SIE

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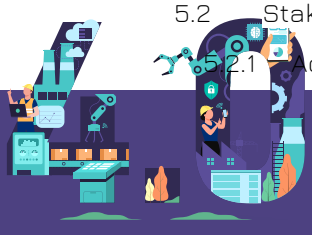

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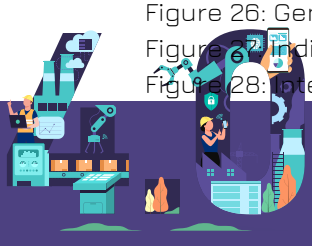

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Glossary of Acronyms

Acronym	Description
AI	Artificial Intelligence
BMC	Business Model Canvas
CAGR	Compound Annual Growth Rate
CNC	Computer Numerical Control
DC	Data Center
DaaP	Data as a Product
Dx.y	Deliverable x.y
DT	Digital Twin
EC	European Commission
ER	Exploitable Result
EV	Electric Vehicle
EU	European Union
GA	General Agreement
IIoT	Industrial Internet of Things
IPR	Intellectual Property Rights

EXECUTIVE SUMMARY

D6.4 Exploitation and value network ecosystem development is the second deliverable of WP6 and is set to satisfy main objectives of RE4DY. On one hand the objectives related with the exploitation and business plan of RE4DY. On the other hand, the objectives linked with the projects value network development and the integrated goal of developing a business plan for RE4DY involving stakeholders and networks.

The deliverable reports the work performed up to M18 related to the action plan to deliver the desired objectives, the tools and consideration towards the next phase of the project, associated with Task 6.3: "Impact Analysis & commercial exploitation". In addition, this deliverable also reports the work performed in the context of Task 6.4 "Value network & data space business development" that complements the exploitation strategy towards the delivery of RE4DY business model and data exploitation, focusing on the stakeholder's analysis and engagement.

More specifically, the deliverable report focuses on assessing the potential impact of RE4DY results through the lens of a market analysis, addressing the industries and technologies most closely associated with the project developments. The foundation for the exploitation of RE4DY is included by providing the list of the Individual Exploitable results and their characteristics. These are the first steps towards the realization of the work plan which is included in this document. In addition, the methodology and tools that will be utilized throughout the project lifecycle to deliver the exploitation objective are presented in this document. Also, the methodological approach and tools to define and illustrate the business model are elaborated. Finally, the activities and consideration towards stakeholders' analysis and engagement are considered in this deliverable in the sense of supporting the business model development and the definition of new business models around data spaces and data as a product concepts.

1 Introduction

RE4DY objectives are to deliver an exploitation plan, including an impact analysis and a concrete business model, develop and engagement plan for RE4DY value network ecosystem focusing primary on Small and Medium Enterprises (SMEs) and collaborations with Digital Innovation Hubs (DIH). In addition, RE4DY is engaged in business innovation for new and in innovative concepts such as Circular Digital Twins, Data as a Product models and Manufacturing data spaces. These objectives, and partners that work to achieve them, are addressed in this document.

1.1 Purpose and Scope

Deliverable 6.4 serves as a compiled report that aims to present a comprehensive overview of the Impact Analysis and Commercial Exploitation of RE4DY. Additionally, it delves into activities associated with the development of the project's value network and the establishment of a data space business. This document represents the initial version of the report, offering insights into early findings and considerations, with a primary focus on the methodologies employed to achieve the outlined objectives. The structure of the deliverable has been organized to present information in a coherent and comprehensive manner.

- Section 1: Provides the introduction and the scope of this document.
- Section 2: Presents the outcomes of the market study conducted. It provides insights into the industries and technologies closely associated with the developments of the RE4DY project.
- Section 3: Articulates the goals and strategy devised for the exploitation of RE4DY.
- Section 4: Delves into the detailed efforts and activities undertaken in formulating the exploitation plan for RE4DY.
- Section 5: Showcases the efforts undertaken in analyzing and engaging stakeholders within the context of the RE4DY project.
- Section 6: Includes the methodology and tools towards RE4DY business plan creation.

2 Market Study

This section focuses on market analysis. We will explore four use case scenarios, each representing a unique aspect of the market. This section provides a comprehensive view of market dynamics. By conducting a detailed evaluation of market size, growth, competitive environment, and other elements, our objective is to deliver insights that showcase the potential of the use cases selected for the project and how RE4DY results can make impact post project. Moreover, our analysis, aims to provide stakeholders, industry experts, and decision-makers with a comprehensive and clear understanding of the markets we're examining. This information not only helps in grasping the current situation but also offers valuable insights for making strategic plans and decisions. It ensures a more informed and successful approach as we navigate these dynamic and changing markets.

2.1 Use case markets

The selection of carefully chosen pilots by RE4DY (Figure 1) reflects a strategic approach to establishing high-economic-value ecosystems, particularly within emerging industrial markets. These pilots serve as tangible demonstrations of the project's objectives, showcasing the practical application and economic potential of resilient manufacturing.

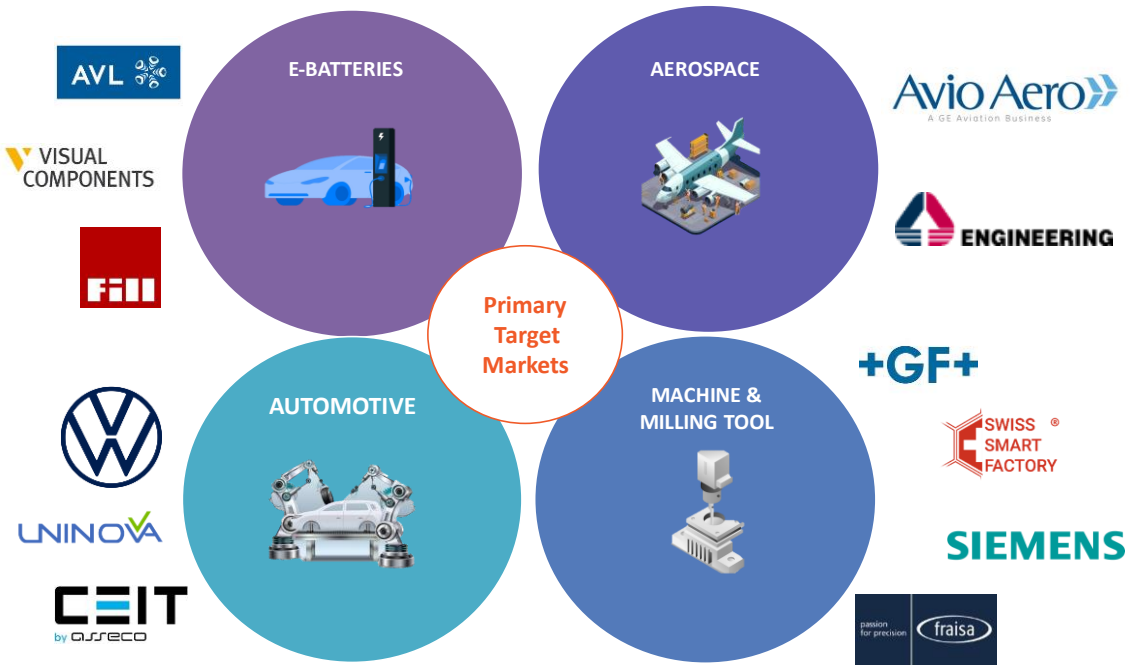


Figure 1: RE4DY industrial markets

2.1.1 e-Battery market

The e-battery market encompasses the activities related to the production, distribution, and provision of energy storage devices known as batteries. These batteries serve as vital components across a diverse area of applications, ranging from consumer electronics and automotive vehicles to renewable energy storage and industrial sectors.

Regarding revenue, the worldwide battery market achieved a valuation of 111.86 billion € in 2022. Projections indicate that it is set to expand significantly, with an estimated value of 423.90 billion € anticipated by 2030. This growth is expected to have a Compound Annual Growth Rate (CAGR) of 16.68% over the forecasting period spanning from 2022 to 2030. In 2022, the Lithium-ion segment assumed a leading position within the market, capturing 40.77% of the global revenue share. This role was largely attributed to its strong presence in the e-mobility sector, where lithium-ion batteries have established a significant share. It is expected that the electric vehicle (EV) industry will continue to be a key driver, reinforcing the dominance of lithium-ion battery solutions in the years to come. Following closely, lead-acid batteries have the second-largest share of the global battery market in terms of revenue during 2022. This can be attributed to the growing demand for rechargeable batteries, particularly in the automotive sector, where applications like starting, lighting, and ignition (SLI) batteries. Additionally, the Lithium-titanate-oxide (LTO) segment emerged as the fastest-growing product category in the global battery market. This growth can be attributed to its unique ability to charge more rapidly than other lithium-ion batteries. Anticipated innovations and advancements that enable fast charging are expected to be key drivers in advancing the growth of the lithium-titanate-oxide market in the foreseeable future. China will have a significant role in the lithium-ion (Li-ion) battery market, with projections indicating that it could represent 45 percent of the total Li-ion demand by 2025 and approximately 40 percent by 2030. This strong position is partly due to the maturity of various segments within the battery supply chain already present in the country. However, the most substantial growth on a global scale is expected to occur in the European Union (EU) and the United States. This growth is driven by recent regulatory changes and a broader trend toward localizing supply chains. As a result, there is a growing need to establish between 120 to 150 new battery manufacturing facilities worldwide between now and 2030 to meet the burgeoning demand. According to Mckinsey, there's a green revolution happening in Europe and across the world. And one of the major shifts leading the way in that revolution is the move to electric vehicles. In 2021, some 6.5 million electric vehicles were sold, which was up almost 110 percent from the year before. And with all these new EVs rolling out into our roads, they need batteries to power them. That's a lot of batteries, and therefore a lot of factories, known as giga factories, to make them, with 30 planned in Europe alone.

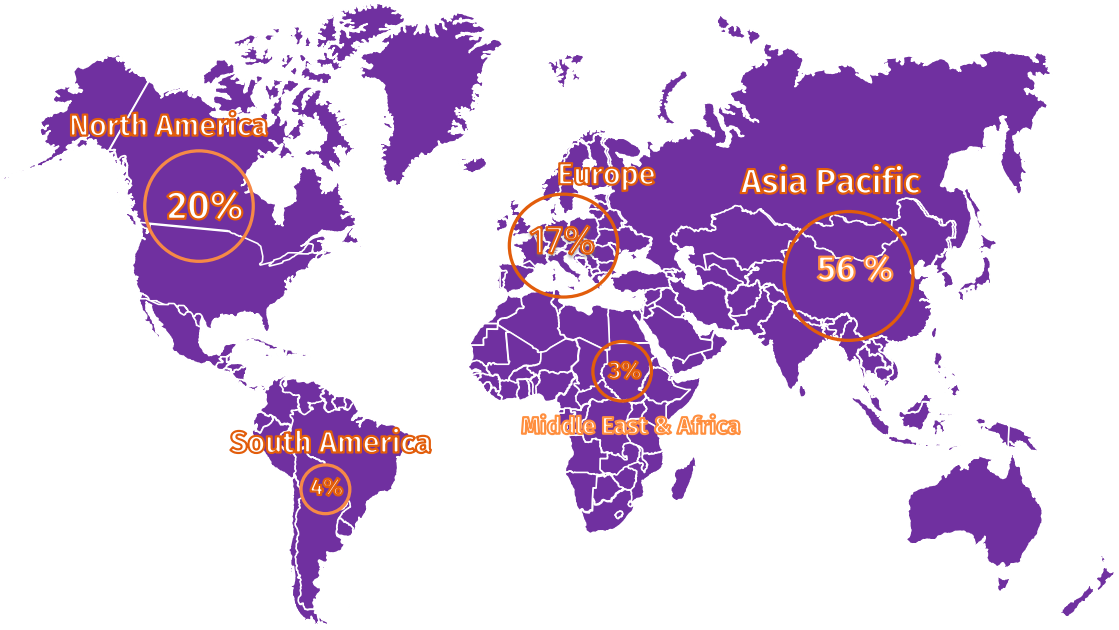


Figure 2: eBattery market regional share

When considering the end-use of batteries, the automotive sector played a pivotal role, contributing the largest market share, accounting for approximately 32.4% of the market in 2022. In the context of applications, the industrial batteries segment secured a significant revenue share of 35.9% in 2022. Furthermore, the automotive batteries segment also made a substantial impact, holding a revenue share of 34.7% in the market in 2022. In 2022, China experienced a surge in demand for batteries used in vehicles, registering a growth rate exceeding 70%. Concurrently, sales of electric cars in China saw a substantial 80% increase compared to the previous year. It's worth noting that the growth in battery demand was slightly moderated by the rising presence of Plug-in Hybrid Electric Vehicles (PHEVs) in the market. Meanwhile, in the United States, the demand for vehicle batteries also demonstrated growth, with an approximate 80% increase in 2022. However, electric car sales in the United States grew at a slightly slower pace, around 55%, during the same period. The average battery size for battery electric cars in the United States expanded by approximately 7% in 2022. Moreover, it's important to highlight that the average battery size for electric cars in the United States remains around 40% larger than the global average, primarily due to the greater prevalence of SUVs in the American electric car market compared to other major markets.

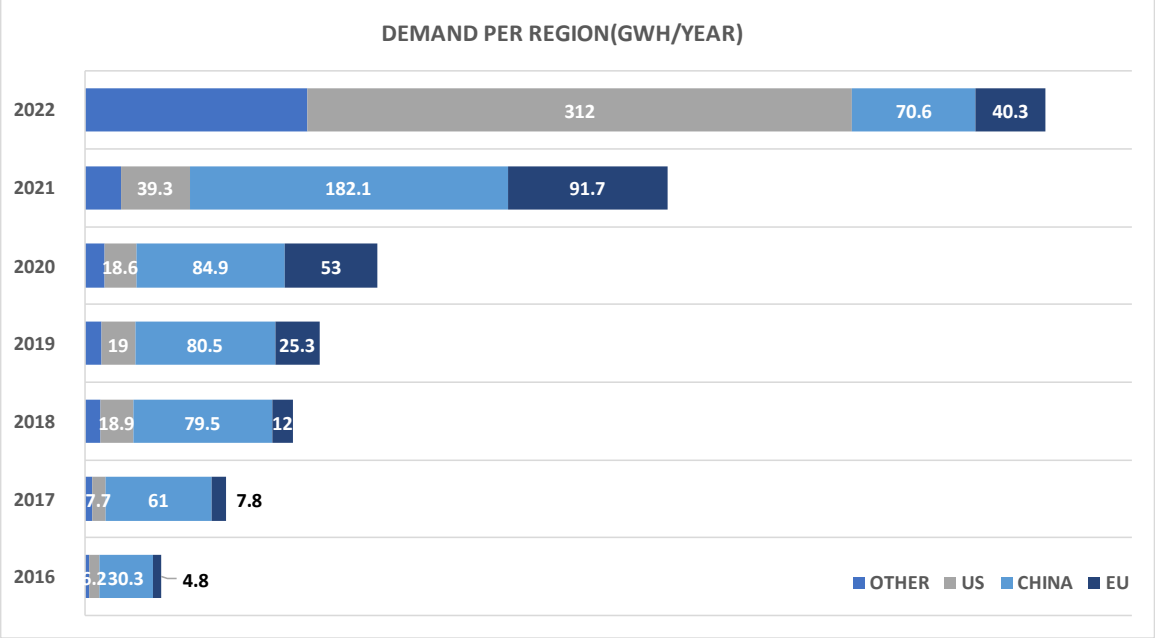
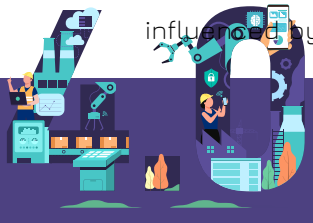


Figure 3: battery regional demand

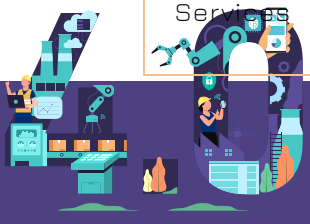
The rapidly evolving electric vehicle (EV) battery market is encountering a series of policy changes, resulting in an environment of increasing challenges and transformation. These changes are raising entry barriers and contributing to market consolidation. In 2021, European battery sales experienced a remarkable growth of 65%, highlighting the robust demand for electric vehicle batteries. Europe witnessed notable developments, with seven of its countries ranking among the top ten in the global battery industry for 2021. These countries include Germany, France, the UK, Norway, Italy, Sweden, and the Netherlands. Germany, one of the leading nations in Europe, recorded an impressive 72% increase in battery sales. This growth can be attributed to the presence of some of the largest electric vehicle manufacturing facilities in Europe, with major players like Tesla, Volkswagen, and the Chinese battery giant, Contemporary Amperex Technology (CATL), all planning to establish significant manufacturing hubs in the country. China, home to leading battery producers like CATL and Build Your Dreams (BYD), is also making substantial strides in expanding its battery manufacturing capacity. With ambitious plans in motion, China's battery production capacity is projected to exceed that of the rest of the world combined, more than tripling its current capacity. Securing a strong foothold in the Chinese battery industry is increasingly seen as a strategic advantage, given the immense market size and the influence it holds in the global arena. Furthermore, state intervention and support have played a crucial role in bolstering Chinese battery manufacturers, fostering their growth and competitiveness. These factors underscore the importance of government policies and industrial strategies in shaping the dynamics of the rapidly evolving global EV battery market. As the industry continues to evolve, the competitive landscape is likely to be influenced by a complex interplay of market forces, policy decisions, and global market



demand. The European Union (EU) recognizes the imperative need to maintain and enhance competitiveness, particularly in the context of the global electric vehicle and battery market. Some of the most prominent companies are displayed in Table 1.

Table 1: EU eBattery companies

EU eBattery companies					
Company	Northvolt (SE)	SAFT (FR)	BMZ Group(DE)	Dräxlmaier Group (DE)	AVL(AT)
Industry Sectors	eBattery, Manufacturing	eBattery, Manufacturing, Energy Storage Systems	Battery systems, Manufacturing	Manufacturing, mobility wiring harness systems	Mobility technology companies for development, simulation, and testing
Industrial activity	Battery developer and manufacturer, specializing in lithium-ion technology for electric vehicles.	Manufacturing of longer-lasting batteries and systems, critical safety applications, back-up power and propulsion	Manufacturing of high-tech battery systems	supplies premium automobile manufacturers worldwide with wiring harness systems, central electrical and electronic components, exclusive interiors, and battery systems for electromobility	Development of innovative mobility systems, including hydrogen engines, hybrid powertrains, battery electric vehicles, and fuel cells
Target market	Automotive, Construction, eMobility, Grid, Industry	Aerospace, Telecom, Oil & Gas, Energy Utilities, Aerospace & Defence	eMobility, Medical, industry, Energy storage	Automotive	Automotive
Product portfolio	lithium-ion cells, cell production lines, Voltblocks, Voltpacks, Voltracks	nickel, lithium-ion, and silver-based batteries-, primary lithium batteries (Li-SOCl2, Li-MnO2, Li-SO2, Hybrid)	e-mobility and Drive systems battery-powered solutions for the industry	Battery systems, Interior systems, Componets systems, electrical systems	AVL eSUITE, Hardware-in-the-Loop (HiL) and Software-in-the-Loop (SiL) testbeds
Services	Supplier of sustainable li-ion	Strategic spare-part management and	cloud, software, and	Hardware and Software development, HV battery	Emobility testing, fuel cell testing, ice/hybrid



	cells and systems	supply, Meter Life Analysis, Battery sizing and configuration	remote services	development and production	propulsion testing, connected development software, simulation as a service
Revenue	41M € (2022)	1B € (2022)	8.8 B € (2019)	5.1B € (2022)	1.86B € (2022)
Employees	3.000	4.000	35.000	74.000	11.200

The adoption of electric vehicles is on the rise due to their potential environmental advantages and reduced dependence on fossil fuels. China has experienced significant EV adoption, with around 4.40% of the 28.08 million vehicles sold in 2018 being EVs, surpassing adoption rates in the United States and Europe. Lithium-ion batteries (LIBs) are the preferred power source for EVs due to their favorable characteristics like high energy density, low self-discharge rates, and extended lifespan. Numerous governments and regulatory bodies have implemented a range of incentives, subsidies, or regulations designed to promote the adoption of electric vehicles, recognizing the potential for EVs to fulfill their objectives. These measures have played a pivotal role in instilling confidence and enthusiasm among consumers for electric vehicles, consequently driving the growth of the market. The commitments made by governments and vehicle manufacturers to transition towards electrification are central to the expansion of the electric vehicle market. Many countries have established ambitious targets and deadlines for phasing out the sale of new internal combustion vehicles (ICVs). In response, automotive companies have significantly increased their investments in research, development, and the production of electric vehicles. This has resulted in a broader range of electric cars with enhanced features, extended driving ranges, and increased affordability. Alongside these supportive policies and the wider availability of EV options, these efforts have not only contributed to market growth but have also bolstered consumer trust and acceptance.

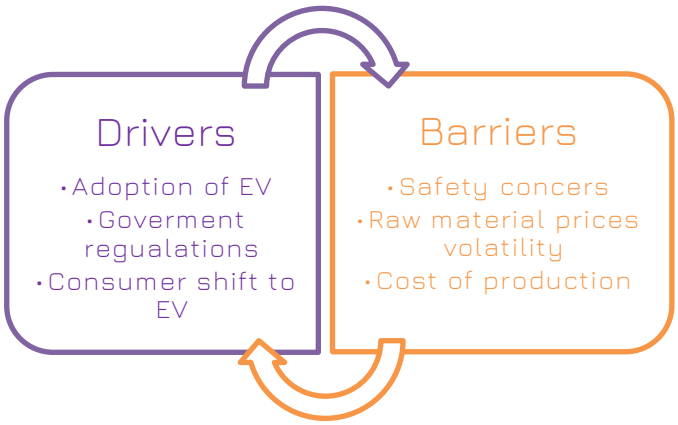


Figure 4: eBattery market drivers and barriers

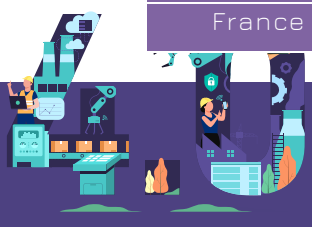
2.1.2 Automotive market

The automotive industry comprises a wide range of companies and organizations involved in the design, development, manufacturing, marketing, selling, repairing, and modification of motor vehicles and it is one of the world's largest industries by revenue. This industry encompasses a wide range of vehicle types, from traditional internal combustion engine (ICE) vehicles to the latest innovations in electric, autonomous, and connected vehicles. The automotive market is not limited to the production of vehicles alone; it also includes associated services, aftermarket parts, and solutions that support transportation needs across the globe. Automotive manufacturing is the process of assembling components to build automobiles, trucks, and other motor vehicles. This process is complex and involves many stages, from designing the vehicle and its components to assembling the parts, testing the vehicle, and finally delivering it to customers.

The market is projected to grow from 3,566 billion € in 2022 to 6,070 billion € in 2030 at CAGR of 6.9%. Europe boasts a significant presence in the automotive industry, with a total of 322 manufacturing facilities involved in the assembly, engine production, and battery manufacturing sectors. Within these numbers, 213 of these facilities are located within the European Union (EU), signifying an increase from the previous year when there were 194 such facilities. These manufacturing plants play various roles within the automotive sector, with 127 of them dedicated to car production, 71 focused on manufacturing buses, 56 engaged in the construction of heavy-duty trucks, and 46 dedicated to producing vans, particularly light commercial vehicles. In addition to these, there are 71 facilities focused on engine production, and 42 specialized in the manufacturing of batteries (Table 2). This significant presence and diversity of manufacturing capabilities within Europe showcase the region's significance in the global automotive industry. According to European Automobile Manufacturers Association (ACEA), based on the type of product and the geographical locations we have:

Table 2: Automotive manufacturing facilities

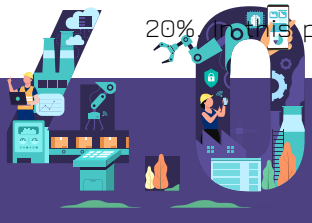
Country	Cars	Vans	Trucks	Buses	Engines/motors	Batteries	Total
Austria	1	1	2	-	2	1	6
Belgium	3	-	2	2	-	2	8
Croatia	1	-	-	-	1	1	1
Czech Republic	4	-	1	3	2	1	9
Finland	1	-	1	-	-	2	3
France	12	4	4	7	6	5	31



Germany	24	10	3	3	14	12	54
Hungary	3	-	-	2	2	1	7
Italy	9	3	3	3	7	2	23
Netherlands	2	1	3	2	1	1	9
Poland	1	3	2	5	7	2	19
Portugal	2	1	1	1	-	-	5
Romania	2	-	2	2	3	1	6
Slovakia	4	-	-	-	1	2	5
Slovenia	1	-	-	-	-	1	2
Spain	8	4	2	5	3	3	16
Sweden	2	-	2	3	3	1	9
EUROPEAN UNION	80	27	28	38	52	38	213
Belarus	2	1	2	1	-	-	4
Kazakhstan	2	2	4	5	-	-	6
North Macedonia	-	-	-	1	-	-	1
Russia	13	6	9	9	6	1	32
Serbia	1	-	1	2	-	-	3
Turkey	4	7	5	7	4	1	16
Ukraine	3	-	1	2	-	-	5
United Kingdom	19	1	4	4	8	2	36
Uzbekistan	3	2	2	2	1	-	6
EUROPE	127	46	56	71	71	42	322

The data offers a snapshot of the automotive landscape, showcasing the distribution of various vehicle types and related technologies manufactured in European facilities. Germany has the highest overall count, followed by France and the United Kingdom.

In September 2023, the European Union's (EU) car market continued its impressive growth streak, marking the fourteenth consecutive month of expansion with a 9.2% increase in new car registrations (Figure 5), totaling 861,062 units. Two of the EU's largest markets, Italy and France, witnessed substantial gains, with increases of 22.7% and 10.7%, respectively. Meanwhile, Germany's market remained stable, with only a slight 0.1% drop compared to September 2022. For the first three quarters of 2023, the EU car market exhibited substantial growth, soaring by 16.9%. However, it's essential to note that despite this year-to-date increase, the market still lags behind the pre-COVID pandemic levels of 2019 by 20%. In this period all of the region's markets, except for Hungary, recorded gains. This



included the four largest EU markets: Italy (+20.5%), Spain (+18.5%), France (+15.9%), and Germany (+14.5%).

A significant trend in September was the rising market share of battery-electric cars, reaching 14.8%, up from 14.1% in the previous year. This marked the third instance this year that battery-electric cars overtook diesel, making them the third most favored choice among new car buyers. Hybrid-electric cars retained their position as the second most-preferred option, capturing a substantial 27.3% of the market. Petrol cars, while still leading the market, saw a slight decline in market share from 35.3% in September 2022 to 34.1% this year. In September, new EU hybrid-electric car registrations surged by 30.5%, driven by robust growth in the bloc's three largest markets: Germany (+44.1%), Italy (+34.8%), and France (+30.2%). This resulted in a cumulative increase of 28.8% for the first three-quarters of the year, accounting for approximately a quarter of the market.

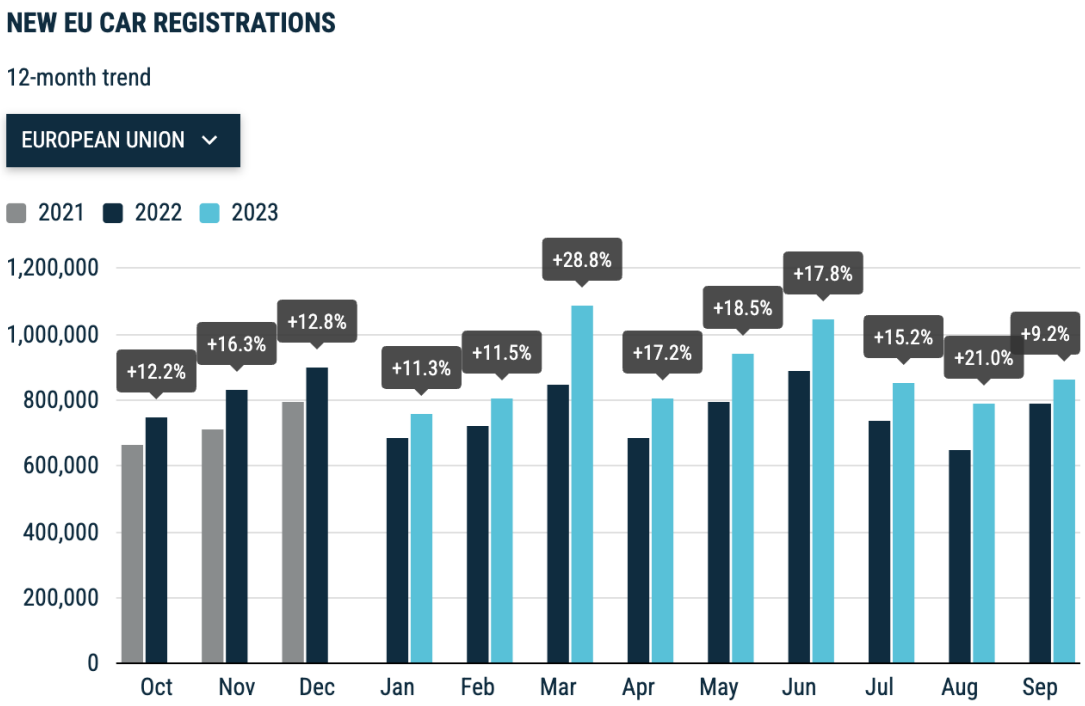


Figure 5: New cars registration rates in EU

The automotive industry stands as a cornerstone of the European economy, playing a vital role in the region's economic growth, innovation, and overall prosperity. Over the decades, it has been a significant contributor, responsible for nearly 7% of the region's Gross Domestic Product (GDP), accounting for nearly 30% of the R&D spending and more than €1 trillion contributions to EU GDP. This industry's also employees around 13 million people, whether through direct or indirect employment, underlining its essential position in Europe's economic landscape (Figure 6).

EMPLOYMENT	Motor vehicle manufacturing (EU)	2.4 million jobs = 8.3% of EU manufacturing employment	2021
	Total (EU manufacturing, services, and construction)	12.9 million jobs = 6.8% of EU employment	2021
PRODUCTION	Motor vehicles (global)	85.4 million units	2022
	Motor vehicles (EU)	13.1 million units = 15.3% of global motor vehicle production	2022
	Passenger cars (global)	68.7 million units	2022
	Passenger cars (EU)	10.9 million units = 15.9% of global car production	2022
REGISTRATIONS	Motor vehicles (global)	81.7 million units	2022
	Motor vehicles (EU)	10.9 million units = 13.3% of global vehicle registrations	2022
	Passenger cars (global)	65.8 million units	2022
	Passenger cars (EU)	9.3 million units = 14.1% of global car registrations	2022
	New cars by fuel (EU)	battery electric 12.1%, petrol 36.4% of market share	2022
	New vans by fuel (EU)	electric 5.3%, diesel 86% of market share	2022
	New trucks by fuel (EU)	electric 0.6%, diesel 96.6% of market share	2022
	New buses by fuel (EU)	electric 12.7%, diesel 67.3% of market share	2022

Figure 6: Automotive industry economic impact

The automotive manufacturing industry is currently at a crossroads, facing new competition, rapidly advancing technologies, and evolving consumer demands. In this dynamic environment, manufacturers must find a balance between future innovation with meeting current customer needs. Moreover, they need to attract talent and reinvent their operations to support this effort innovation and keep them competitive in the evolving automotive landscape. The retail automotive industry can be characterized as competitive economic environment. Some important companies in the industry are presented below:

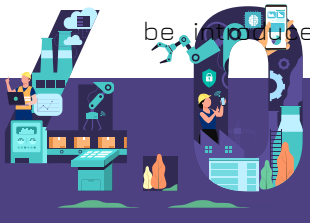
Table 3: EU automotive manufacturers

EU Automotive manufacturers					
Company	Stelantis (NL)	BMW (DE)	Mercedes-Benz Group AG (DE)	Renault SA (FR)	VW Group (DE)
Industry Sectors	Manufacturing, Automotive	Manufacturing, Automotive	Manufacturing, Automotive	Manufacturing, Automotive	Manufacturing, Automotive
Industrial activity	Designs, engineers, manufactures, distributes, and sells vehicles, components, and production systems	Designs, engineers, manufactures and sells vehicles automobiles and motorcycles	Designs, engineers, manufactures, and sells automobiles	Designs, engineers, manufactures, and sells automobiles	Designs, engineers, manufactures, and sells automobiles
Target market	Customers, businesses	Customers, businesses	Customers, businesses	Customers, businesses	Customers, businesses
Product portfolio	Abarth, Alfa Romeo, Fiat, Citroen, Chrysler, Dodge, DS, Fiat, Jeep, Lancia, Maserati, Opel, Peugeot, RAM, Vauxhall, free2move,Leasys	BMW, BMW motorad, MINI, Rolls Royce	Mercedes – Benz, Maybach, Smart Mercedes AMG High Performance Powertrains	Renault, Alpine, Dacia, Mobilize	Audi, Volkswagen, Skoda Auto, SEAT, Porsche, CUPRA, Lamborghini, Bentley, Ducati,
Services	Manufacturing and design of cars, financial services	Manufacturing, BMW financial services, Design works, multi-mobility service	Manufacturing, , Mercedes Benz Mobility,	Manufacturing and design of cars, financial services	Automobiles, commercial vehicles, internal combustion engines, motorcycles, turbo machinery, financial services, fleet management
Revenue	180 B € (2022)	216M € (2022)	162 B € (2023)	46.3 B € (2022)	294.2 B € (2022)
Employe	272.367	150.000	172.425	170.158	667.647

In March 2022, Ford made a landmark announcement signaling its substantial strides towards an electric future in Europe. The company unveiled plans to introduce three electric passenger vehicles and four new electric commercial vehicles in the European market by 2023. Furthermore, Ford's ambitious vision includes the goal of selling over 600,000 electric vehicles in Europe by the year 2026. These initiatives reflect Ford's commitment to a more sustainable and electrified automotive landscape, solidifying its position as a major player in the region's electric vehicle market. The renowned Chinese electric vehicle company, BYD, has set its sights on establishing its car manufacturing facility in Europe, and Hungary has been selected as the host location. BYD's footprint in Europe extends to key markets, including Germany, France, the United Kingdom, Spain, and the Scandinavian countries. It's worth noticing that the company already operates an electric bus factory in Hungary, which started operations in 2016. This expansion represents BYD's strategic move to strengthen its presence in the European automotive market, reflecting the growing demand for electric vehicles in the region.

The automotive industry is continually shaped by various factors, and it faces several challenges. Manufacturers must carefully plan their production capacities to achieve economies of scale, and these plans are often tied to economic cycles, making the industry susceptible to economic conditions. Capacity decisions significantly impact the economics of the industry, influencing vehicle pricing and production costs. Consumer demand for choice is on the rise, with more vehicles being tailored to individual preferences. Safety and fuel economy are paramount concerns for consumers, spurred by rising fuel prices and a growing awareness of safety issues. This has led to the inclusion of more safety features and onboard electronics and telecommunications systems in vehicles, and consumers are willing to pay more for vehicles with enhanced safety. Several megatrends are driving changes in the industry. These include the advancement of autonomous vehicles, the utilization of data from connected vehicles, the rise of car-sharing programs, alternative transportation initiatives, and the shift towards electric vehicles. The increased use of advanced technology and the production of electric vehicles has revolutionized traditional manufacturing processes. This transformation has made some traditional assembly line production methods outdated.

Global competition among manufacturers and market moves have categorized automakers into three tiers. The first tier includes GM, Ford, Toyota, Honda, and Volkswagen, while the remaining tier manufacturers are exploring consolidation or mergers to compete with the first-tier companies. Also, Automotive companies are harnessing technology to address competitive pressures, meet customer expectations, enhance quality, and manage costs. Technological advancements allow manufacturers to add value to their vehicles and meet environmental regulations. New features expected to be introduced include advanced route guidance, inter-model route planning, lane



guidance, and proximity radars for speed control and warning systems. In this sector, consumers consistently demand innovation and technology-driven advancements, shaping the future of the industry towards more fuel-efficient, safer, comfortable, and low-emission vehicles. On the other hand, disruptions in the supply chain, such as shortages of critical components can significantly impact the automotive industry. These shortages can lead to production delays, increased production costs, and a backlog of orders. As a result, automakers may not meet consumer demand, leading to potential loss of market share and revenue. Companies need to diversify suppliers, stock critical components, and implement more resilient supply chain strategies. Labor workforce shortages can disrupt manufacturing operations, leading to production delays and increased costs as well. Workforce shortages, especially in specialized fields like electric vehicle manufacturing, can potentially hinder growth. In addition, adapting to new manufacturing processes, such as those for electric vehicles, may also require retraining and upskilling the workforce. Government policies related to trade, tariffs, and taxation can impact the automotive industry's competitiveness. Tariffs on imports or exports can increase production costs, affecting pricing and market access. Changes in trade agreements can disrupt established supply chains. Taxation policies can influence consumer purchasing decisions and the overall cost of vehicle ownership. Companies need to closely monitor and adapt to changing policies to remain competitive. In conclusion, the automotive industry is undergoing a significant transformation driven by consumer demands, technological advancements, and global competition. Consumers seek vehicles, emphasizing safety, fuel economy, and innovative features. Megatrends like autonomous vehicles and the shift to electric cars are shaping the industry's future. However, challenges such as supply chain disruptions, labor shortages, and evolving government policies can impact growth. Automotive companies must adapt, invest in technology, and navigate these challenges to thrive in this competitive landscape.

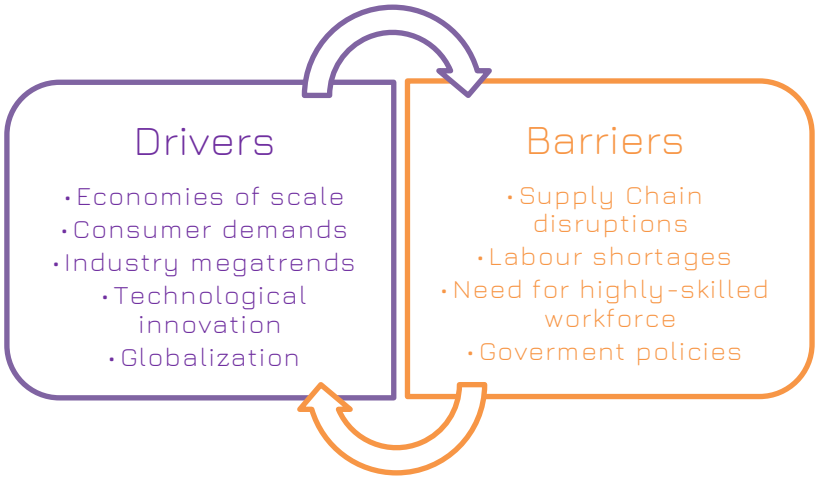


Figure 7: EU automotive market drivers and barriers

2.1.3 Aeronautics market

Aerospace manufacturing encompasses the entire procedure of creating, fabricating, and assembling the components for the development of aerospace vehicles, the maintenance, repair, and overhaul (MRO) as well as the critical components that consist of parts like engines, wings, fuselages, landing gear, and other essential elements. The production of aerospace parts entails the utilization of specialized materials, precision machinery, and advanced technologies to guarantee the attainment of high-quality and secure components. The aerospace parts manufacturing sector is subject to regulations aimed at ensuring adherence to safety and quality standards established by both national and international bodies.

The global aerospace parts manufacturing market has been categorized based on type, applications, and geographical regions. In terms of type, the market can be subdivided into aircraft manufacturing, engines, avionics, cabin interiors, system and support, insulation components, and equipment. Among these, the insulation components and equipment category held the largest market share at approximately 22.82% in 2022. These crucial components and equipment are essential for all types of aircraft, providing protection against excessive heat generated by the engine. Regarding applications, the market can be segmented into military, commercial, and business aircraft. In 2022, the commercial aircraft and business aircraft segment dominated the market, accounting for approximately 56.78% of the total share. Commercial aviation encompasses various general flights and all commercial air transportation and aerial work activities. Commercial aircraft businesses utilize airplanes to transport passengers, cargo, or mail for a fee or rental. It's worth noting that all past commercial aircraft have been powered by gas turbine engines, either turbofan or turboprop. In 2022, the aerospace parts manufacturing market in North America dominated the sector, holding the majority of revenue share at 50.5%. The North America economy presents a highly favorable environment for aircraft manufacturing, primarily due to the growing number of aging aircraft fleets in the region. The replacement of these aging aircraft is prompted by their declining operational efficiency and the revenue needs of the operating airlines. Additionally, the anticipated rise in per capita income is projected to stimulate an increase in air travel passengers, consequently driving up the demand for both aircraft and their associated components. In 2022, the Asia Pacific region had a noteworthy market share, and it is anticipated to expand at a compound annual growth rate of 7.3% by 2030. This growth is attributed to the advancing developments in the aviation sector within the region, driven by the economic progress of countries like Japan, China, and others. The aerospace parts manufacturing market in Europe reached a value of 273 billion € in 2022.

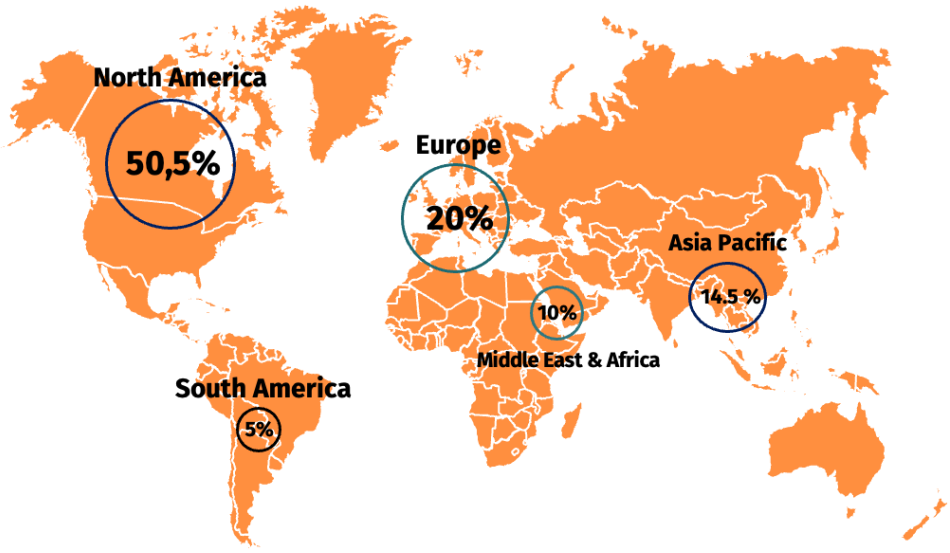
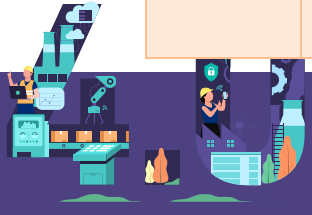


Figure 8: Aeronautics market regional market share

Over the forecast period, the growth of the European aerospace and defense industry is projected to outpace the United States. Despite experiencing improved performance amid economic slowdowns and uncertainties in recent years, the European industry is characterized by a high level of concentration, with major players contributing significantly to the overall revenue. Companies in the aerospace parts manufacturing market engage in competition by emphasizing in technology, design, product performance, and compliance with customer specifications. Moreover, factors like on-time product delivery, market reputation, customer service and pricing also have impact on the competitive landscape. Notable companies in the EU aerospace parts manufacturing market are presented in Table 4, providing insights into the industrial interest of these companies.

Table 4: EU aerospace manufacturers

EU Aeronautics manufacturers					
Company	ITO Aero (ES)	OGMA (PT)	Lufthansa Technik (DE)	Rolls-Royce (UK-DE)	Avio Aero (IT)
Industry Sectors	Aerospace, Aviation, Manufacturing	Manufacturing, Aerospace, Aviation, Welding, Machinery	Aerospace, Manufacturing	Aerospace, Aviation, Manufacturing	Manufacturing, Aerospace, Aviation
Industrial activity	Design , production, and maintenance of componets	full-service MRO, providing maintenance , repair, painting,	Manufacturing and design of military aircrafts , business	Manufacturing propulsion systems and provision of aircraft gearboxes,	Manufacturing, design and maintenance of civil and military



	and systems for civil and aeronautical industry	fleet management, training and engineering services for a wide variety of commercial, executive, and military aircraft, engines and components	jets and space systems	twin-shaft engines, small gas turbines, and electric drive systems. The company also develops prototypes and products for motors, inverters as well as control and power distribution systems.	aeronautics subsystems and systems. Additive manufacturing to produce aeroengine transmissions, turbines and combustors
Target market	Tier 1 supplier to aircraft engine manufacturers and OEM EU defense consortia	Civil and executive aviation, Defence Industry	Defense Industry, Civil aerospace, Integrated services for OEMs	Civil aerospace, Electrical and Defence industry, Civil nuclear, Power Systems	Commercial and Military Aviation
Product portfolio	Turbines, Compressors, Nozzles, radial structures , external castings	Composites, metallic structures, machining	technical solutions and modifications for aircraft, cabin customization	Trent engines, Vertical Landing Lift System®, EJ200 engine, MT30 gas turbine, modular reactors, MTU Powerpacks	Mechanical and power transmissions , Engines, turbine modules
Services	- Manufacturing of products - Experimental services (test facilities) - Engineering at complete engine level	- maintenance services for defense aviation, engines, and components - manufacturing for OEMs (metallic structures, software, composites) - engineering on aircrafts and products	Provider of aircraft maintenance, repair, overhaul, and modification services for civil aircraft(commercial and executive) and special mission aircraft.	- Manufacturing of engines -Desing and manufacture of defense products -Electric propulsion and engine systems	Manufacturing of engines and design, certification, MRO of aircraft engines, modules and componets
Revenue	1.014M € (2022)	216M € (2022)	5.6 B € (2022)	13,5B € (2023)	1.3 B € (2023)

Employees	4.200	1700	20.500	50.000	5.700

In June 2023, Rolls-Royce introduced its latest small gas turbine designed for powering hybrid-electric flight. This turbogenerator system is intended to complement the company's Electrical Propulsion portfolio, offering scalable power options ranging from 500kW to 1200kW. This innovation enables an extended range on sustainable aviation fuels and, in the future, through hydrogen combustion. Moving to July 2023, Safran inked a comprehensive term agreement with Air France Industries KLM Engineering & Maintenance (AFI KLM E&M) focused on the maintenance of Auxiliary Power Unit Generators, which spans a duration of five years and also incorporates a Power By the Hour contract. Under these agreements, Safran Electrical & Power will undertake the repair and servicing of Auxiliary Power Unit Generators at its facility situated in Pitstone, UK. In December 2021, Intrex Aerospace formed a strategic partnership with Eaton and UTC Aerospace to establish a new business strategy aimed at strengthening their presence in the aerospace parts market. In April 2022, a significant milestone occurred within the global industry as Infosys and Rolls Royce joined forces to launch an Aerospace engineering and digital innovation center in India. These developments collectively demonstrate the aerospace sector's resilience, adaptability, and determination to shape a new interconnected and sustainable future for the industry. The industry continues to evolve, offering new solutions, services, and partnerships that will have a huge impact on aerospace innovation and growth.

The aerospace industry continually enhances its aircrafts to meet the increasingly demanding requirements of its passengers, introducing a range of new services. Achieving this goal often involves the renovation of existing aircraft or the construction of entirely new-generation aircraft. This evolution to cater to the modern demands drives the development of numerous components, propelling the aerospace parts manufacturing market in Europe forward. The increased rate of fleet replacements is anticipated to accelerate aircraft production, driving industry growth. The extended service life of aircraft enables Maintenance, Repair, and Overhaul (MRO) businesses to cater to existing fleets, thereby boosting demand. Moreover, airlines contemplating fleet expansions may choose to reintroduce older aircraft or extend their service life, further stimulating growth in the aerospace components manufacturing market. Technical innovations and a rising demand for aircraft designed for specialized missions are expected to contribute to global market growth. The growing demand for fuel-efficient, lightweight, and next-generation aircraft is a major driving force behind the aerospace components manufacturing industry. As aircraft production accelerates, this demand is set to lead to increased fleet maintenance, technological advancements, and a surge in demand for aircraft designed for specific purposes. The industry is actively working to enhance collaboration among key players in aerospace component production, further propelling its growth. While the aerospace industry continues to expand, there are certain challenges that may hinder its growth. The

volatility in the prices of raw materials can impact production costs and profitability within the aerospace industry. Sudden price fluctuations can pose challenges in cost management and planning. The industry is subject to strict regulations to ensure safety and compliance. Adhering to these regulations can be costly and time-consuming, affecting production and operations. The aerospace sector often requires significant capital investment for research, development, and manufacturing. Managing these capital expenditures can be a complex and resource-intensive task. Finally, the increasing complexity of aerospace products has led to rising development costs and financial risks. These expenses have surpassed the resources of even the largest European companies, resulting in a declining number of new programs launches and affecting the industry's ability to innovate.

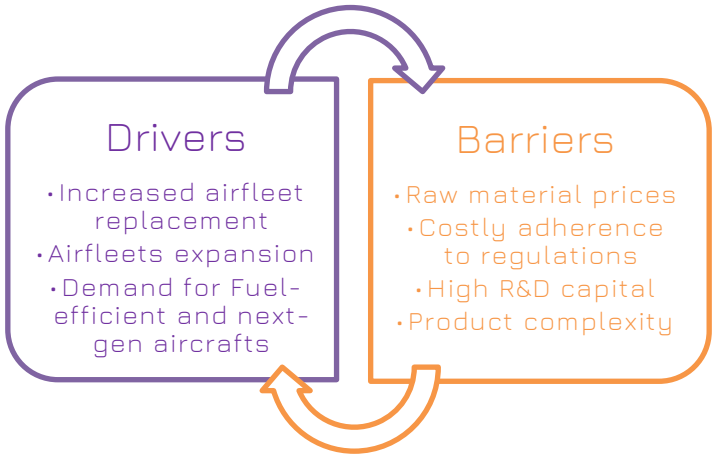


Figure 9: Aeronautics parts market drivers and barriers

2.1.4 Machining solutions market

A machine tool is a piece of machinery designed for handling or machining metal and other rigid materials, typically through processes such as cutting, boring, grinding, shearing, or various forms of deformations. The machine tools industry is generally categorized into two main segments: metal-cutting machines and metal-forming machines. The Machine Tools Market is segmented based on various types of machine tools, including.

- Milling Machines: These machines are used to perform operations like cutting, shaping, and drilling by removing material from the workpiece using rotary cutters.
- Drilling Machines: Drilling machines are designed for creating holes in various materials, including metals, wood, and plastic, by rotating a drill bit.
- Turning Machines: Turning machines, such as lathes, are used for shaping workpieces by rotating them while a cutting tool is applied to create symmetrical parts.

- Grinding Machines: These machines use abrasive wheels to perform precision grinding, smoothing, and finishing operations on workpieces.
- Electrical Discharge Machines (EDM): EDM machines utilize electrical discharges for machining operations, such as cutting and shaping, and are often used for complex and precision work.
- Additive Manufacturing: Additive manufacturing, often referred to as 3D printing, is a rapidly growing segment of the market. It involves the creation of objects layer by layer, typically from materials like plastics, metals, or ceramics, using computer-aided design (CAD) data.
- Laser Technologies: Laser technologies are widely utilized in machining processes. This segment includes laser cutting machines, which use laser beams to cut and shape materials with high precision, as well as laser engraving and marking machines for adding detailed markings and designs to workpieces.

The Machine Tools Market size is estimated at 100.63 € billion in 2023 and is expected to reach USD 116.19 € billion by 2028, growing at a CAGR of 2.92% during the forecast period (2023-2028). The milling segment accounted for a significant portion of the market's revenue share in 2022, approximately 77.1%. The automotive industry's increased focus on manufacturing efficient auto parts has driven the demand for machine tools. In terms of regional segmentation , Asia Pacific played a significant role in the global machine tools market, contributing to approximately 55.0% of the revenue share in 2022. The region's rapid growth is driven by its automotive and manufacturing sectors. More specifically China is expected to become one of the most promising markets in Asia Pacific, thanks to favorable government support for investments in the manufacturing sector.

The Machine Tools Market exhibits a relatively fragmented landscape, with a mix of global players and small to medium-sized local companies. Key regional hubs for the market include China, Germany, Japan, and Italy, which are known for their strong presence in the manufacturing and machine tools sectors. Companies operating in this market are increasingly emphasizing the development of automated solutions, reflecting a growing preference for automation in machining processes. Moreover, the industry is witnessing a trend of consolidation through mergers and acquisitions. These strategic moves enable companies to expand their reach into new market areas and acquire new customer bases.

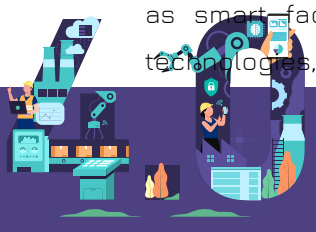
Notable competitors in the EU market are presented in the table below.

Table 5: EU machine tools providers

EU Machining Solution providers				
Company	DMG Mori	Heller Group	KOMAX	+GF+
Industrial Sectors	Metal-cutting machine and high precision tools	Milling machines and tools	Automation, Machinery, manufacturing equipment	Milling Machinery, tools and mold-making, Automation
Industrial Activity	-Machine tools segment: turning, milling, advanced technologies - Software solutions for the automation of machine tools	State-of-the-art CNC machine tools and manufacturing systems for metal-cutting machining	cutting-edge technical solutions for automated wire processing	Solutions provider in Milling, EDM, Laser technologies, Additive manufacturing, Tooling, Automation, Services and Training
Target market	Aerospace, Die & mold, Automotive, Medical	Automotive, Mechanical engineering, Aerospace, Fluid technology	Automotive, Aerospace, Data/telecom	Automotive, Aerospace, Medical, Packaging, Electronic componets
Product portfolio	- turning and milling machines, - Advanced Technologies, such as ULTRASONIC, LASERTEC and ADDITIVE MANUFACTURIN	-CNC profitrainer -milling/turning -machining centers, -4- and 5-axis machining centers, -coating modules, -machines for crankshaft and camshaft	- wire machines and componets, -marking systems, -Automated platform data wire -process modules	-milling machines -wire-cutting EDM -Die-sinking EDM -Additive manufacturing - Step-tec/spindles - System 3R
Services	-Process Integration, - Machine Automation, -Green Transformation	- HELLER Machine Retrofit - Spare parts, - componets repair	- Maintenance(calibration , inspection), -Installation and setup -Repair and spare parts	-Advanced diagnosis - Predictive maintenance -Spare Parts repair - Operational steering - Certification and Trainings
Revenue	2.3B € (2022)	435M € (2022)	621M € (2022)	4.2B € (2022)
Employees	6.800	2.600	3.400	3.500

In December 2022, EIT Manufacturing, the largest innovation community in the European industry, collaborated with AMT – Advanced Machine Tools, a biennial event showcasing the latest innovations in machine tools, machinery deformation, cutting and forming, instruments, components, accessories, and their associated industries. This collaboration was established to promote innovation and digital transformation in the metal industry. By signing the agreement, EIT Manufacturing and AMT opened opportunities for industrial manufacturing specialists in Europe. In September 2022, HELLER Machine Tools announced a strategic partnership with TITANS of CNC, Inc. The agreement focuses on cooperation in machining technology, processes, and practical applications. As part of this partnership, TITANS of CNC agreed to install two 5-axis machining centers at their Texas facility: the HF 5500 with the fifth axis in the workpiece and the CP 6000 with the fifth axis in the tool, along with a Round Pallet Storage System. In August 2022, the CHIRON Group made a significant acquisition by purchasing HSTEC, a specialized company in fixtures and spindles located in Croatia. This strategic move is aimed at bolstering the CHIRON Group's core areas of expertise, which include main components, motor spindles, and turning spindles, for their machining centers. This acquisition represents a step toward enhancing their capabilities and further solidifying their position in the industry. As the industry continues to evolve, these collaborations demonstrate the dedication of these companies to staying at the forefront of technology and manufacturing. They also highlight the potential for further advancements in machine tools and the broader manufacturing sector. Overall, these partnerships are poised to shape the future of the machine tools industry by driving innovation, efficiency, and competitiveness.

The machine tools industry is on a consistent growth, and this can be attributed to several key factors. One significant contributor is the adoption of advanced technologies, such as numerical control solutions, which plays a pivotal role in ensuring the production of standardized products. These technologies not only enhance product uniformity but also minimize the presence on human labor, leading to an overall boost in production efficiency. Furthermore, the pivotal drivers of demand for metal forming machines have historically been the defense, aerospace, and automobile sectors. These industries, characterized by their need for precision manufacturing, consider machine tools as a critical part to their operations. As these sectors continue their expansion, the demand for machine tools is expected to follow suit. Another development is the growing adoption of additive manufacturing within the market. Manufacturers are shifting towards cost-effective processes. The adoption of autonomous tools is set to have substantial growth, primarily driven by the proliferation of smart factories and the increased investment by manufacturers in cutting-edge solutions. According to the Capgemini Digital Transformation Institute, approximately 43% of the world's factories are already operating as smart factories. Another 33% have concrete plans to implement these smart technologies, and the remaining 8% are likely to embrace smart solutions in the coming



years. Industrial automation encompasses a spectrum of advanced technologies, including Industry 4.0, robotics, the industrial internet of things (IIOT), artificial intelligence, and more. Machine tools operate in real-time to exercise control over various aspects of the manufacturing process. The growing significance of these tools, combined with the rapid expansion of industrial automation, is expected to drive the growth of the machine tools market in the years to come. However, it's essential to acknowledge that changes in the global economy can occasionally introduce disruptions to the market. The expenditures within the manufacturing industry often correspond to its growth patterns, and these fluctuations can impact the machine tools market positively or negatively. The machine tools industry faces several pressing challenges. There is a significant shortage of skilled workers, especially in roles like machinists and CNC operators. This scarcity of talent is not limited to machine tools but extends to the broader manufacturing sector. Also, the industry has witnessed the impact of supply chain disruptions, with issues like material shortages, price fluctuations, and trade restrictions causing operational issues. Next, the industry requires substantial capital investment for equipment for advanced machines and robotics. This financial barrier can be particularly challenging for small and medium-sized businesses that may lack the necessary resources for such investments. To mitigate this, alternative models like equipment-as-a-service or robots-as-a-service subscriptions should be considered. These models offer more flexible and financially affordable options for businesses. The future growth of the machine tools industry is promising, driven by technological advancements and evolving market dynamics. However, it is crucial to adapt to global economic changes, which can potentially introduce disruptions to the market. The industry's future is characterized by innovation and adaptability.

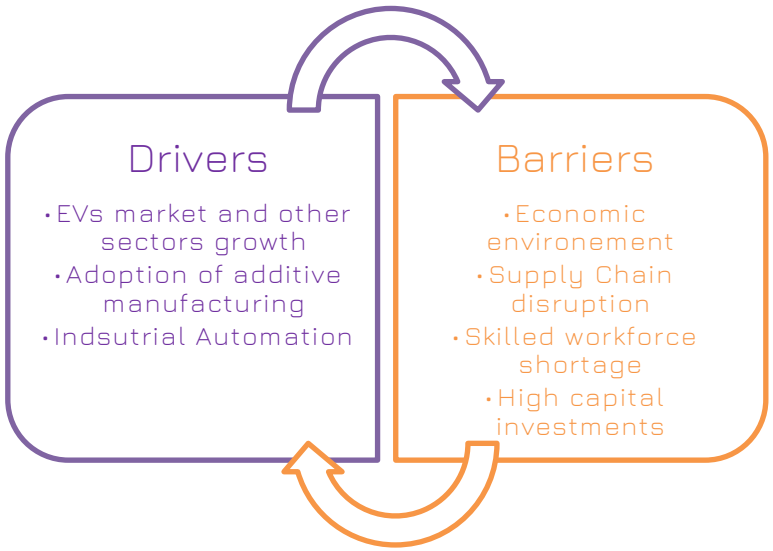


Figure 10: EU Machine Tools market drivers and barriers

Cutting tools are crucial in manufacturing, particularly in producing general machinery, automobiles, aviation and aerospace, energy, medical equipment, rail transit, molds, machine tools, and other industries. The automotive manufacturing process heavily relies on cutting tools as they are one of the key components of the process. The traditional procedures have been replaced with new techniques like high-speed cutting, dry machining, hard machining, and advanced cutting technology. Cutting tools find application in a wide array of manufacturing and machining procedures, including drilling, milling, turning, and grinding. The choice of cutting tools is of paramount importance as it significantly impacts the efficiency and quality of the machining process. A diverse range of cutting tools is available, each with distinct features and purposes. The most critical component of a cutting tool is its cutting edge, the part that meets the workpiece. Cutting tools can also be coated with various materials to enhance their durability and performance. Cutting tools are indispensable in manufacturing and machining. Understanding the types, characteristics, uses, proper selection, and maintenance of cutting tools ensures efficient and high-quality machining processes.

Cutting tools need to exhibit high levels of hardness (for wear resistance), heat resistance, and toughness (to resist chipping) to ensure their durability and effectiveness when cutting materials. Common materials used for cutting tools, in decreasing order of hardness, include diamond, CBN (cubic boron nitride), cemented carbide, and HSS (high-speed tool steel). It's important to note that there's an inverse relationship between hardness and toughness, and the choice of cutting tool material depends on the work material's properties and shape. Besides the material, the shape of the cutting edge is a crucial factor.

The global cutting tools market was valued at 9.50 billion € in 2022 and is expected to reach 13.26 billion € by 2028, growing at a CAGR of 5.72% during the forecast period. Europe is the main market with a 20% share, followed by North America with about 18%.

The North American region was forecasted to have a significant share in the global cutting tools market. The driving factors behind this included the increasing demand in sectors such as automotive, construction, and food and beverage. Furthermore, the industry was expected to benefit from the growing government initiatives to promote electric vehicles, which are becoming increasingly important in the automotive landscape. The highly populated economies of India and China were identified as major contributors to the demand for the automotive industry in the Asia-Pacific (APAC) region. Additionally, Japan, India, and China all boasted a substantial original equipment manufacturer (OEM) manufacturing presence. These factors together were expected to fuel the growth of the cutting tools market in the APAC region. The global cutting tools market is characterized by low concentration and intense competition among the key players. In this dynamic landscape, vendors are enhancing their value propositions to establish a robust market

presence. Presently, the cutting tools market exhibits a high level of fragmentation and is primarily led by major vendors, while there are domestic tool manufacturers that produce cutting tools tailored to local demands and regulations, contributing to the diversity of the market. Notable companies in the EU manufacturing market are shown in Table 6:

Table 6: EU Cutting tools providers

EU Cutting Tools providers				
Company	EMUGE-FRANKEN (DE)	Big Kaiser (CH)	Sandvik Coromant (SE)	FRAISA (CH)
Industrial Sectors	Manufacturing , Precision tools , cutting tools	Manufacturing , Precision tools , cutting tools	Manufacturing, special cutting tools	Manufacturing , Precision tools ,cutting tools
Offering	Manufacturer and supplier specializing in precision tools and cutting tools	High precision tool systems and tool holder solutions	manufacturer of tools for turning, milling, drilling and holding systems	Manufacturer of cutting tools for metal processing
Target market	-Metalworking, -aerospace, -medical device - manufacturing, -automotive	- Automotive, - Mold-making - medical - Aerospace - Metalworking	-Aerospace, -Automotive -Medical and healthcare - Construction - Industrial manufacturing	- Tool making - Machining - Medical tech - Aerospace - Watch industry -precision engineering
Product portfolio	Drilling technologies, Milling Tools, clamping technology, threading tools	Turning tools, measuring instruments, damping tools, cutting tools, Tool holders	Tooling systems, digital machining, milling and drilling tools, turning and threading tools	Carbide and HSS millin g tools , indexable insert milling tools, taps and formers, thread milling cutters, carbide drills
Services	supplying custom tools, system solutions, regrinding, delivery services. Technical consulting	designs, manufactures and markets premium high-precision tooling systems and solutions	- Product Selection Guidance, - Engineering Support -New Product Design and Development - Custom Manufacturing	- RETool services - ToolCare - CocneptTool -ToolSchool
Revenue	150M € (2022)	16M € (2022)	10.5B € (2022)	108M € (2022)
Employees	1.900	900	7.900	536

The cutting tools market experiences growth driven by various factors, including industrial expansion, technological advancements, and the demand for precision and efficiency in manufacturing processes. Notable progress in cutting tool materials, coatings, and designs has resulted in improved tool longevity, cutting speeds, and overall productivity. The cutting tools market exhibits a strong correlation with overall industrial growth. As industries like automotive, construction, and manufacturing expand, the demand for

cutting tools increases. The growing adoption of automation across various sectors, especially in manufacturing, fuels the demand for advanced cutting tools to meet the demands of automated processes. Aerospace and automotive industries often need precise cutting tools for the manufacturing of complex and high-precision components. Their growth has a positive impact to the cutting tools market. Overall, the cutting tools market is driven by a combination of industrial, technological, and consumer trends, making it an evolving sector within the manufacturing industry. The metal-cutting tools market faces a significant challenge in the form of fluctuating raw material prices, which hinder its growth. Various materials, including iron, steel, aluminum, stainless steel, titanium, copper, and other alloys, are essential for manufacturing machine tools used in drilling, boring, lathes, gear cutting, grinding, and polishing machines. These raw materials constitute approximately 48% of the overall manufacturing cost of machine tools. The volatility in raw material prices affects the pricing strategies of machine tool manufacturers. Furthermore, the need to train the workforce affect the overall cost. These factors collectively contribute to increased manufacturing costs, which ultimately impact the growth of the global cutting tools market.

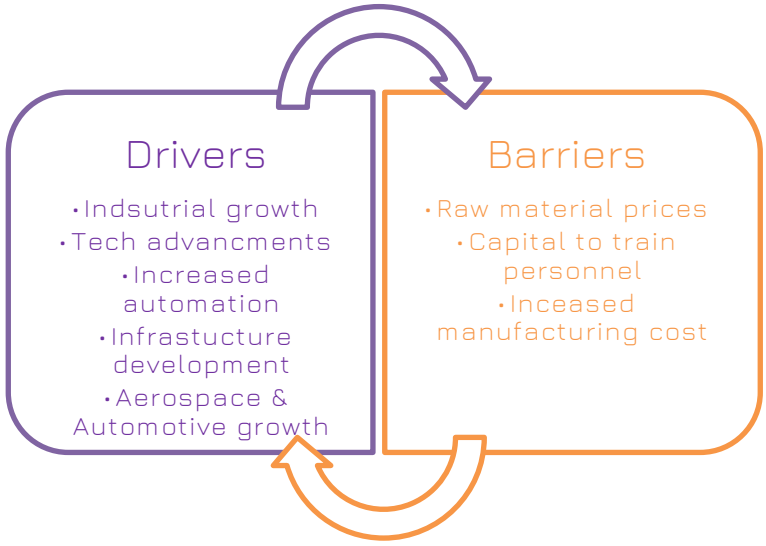
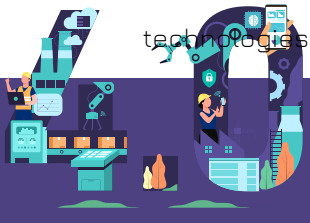


Figure 11: EU cutting tools market drivers and barriers

2.2 Technological segments analysis

RE4DY has strategically chosen the pilots to demonstrate the project results aimed at manufacturing value ecosystems. These initiatives are built upon the successes of previous digital manufacturing demonstrations and projects, effectively laying the groundwork for the emerging European Industrial Data Spaces. These ecosystems will focus on addressing four advanced manufacturing use cases enabling a set of technologies which will be addressed for a market perspective in this section:



- Connected Logistics Design & Planning: Streamlining and optimizing the logistics design and planning process through enhanced connectivity in automotive use case.
- Collaborative Ecosystem for Electric Battery Product/Production System Engineering: Creating collaborative ecosystems to improve product and production system engineering for electric batteries in battery use case.
- Collaborative Ecosystem for Integrated Machine Tool Performance Self-Optimization: Enhancing machine tool performance through collaborative ecosystems with a focus on self-optimization in machine and tools use case.
- Cooperative Multi-Plant Turbine Production with Predictive Quality Chains: Implementing cooperative strategies for multi-plant turbine production while emphasizing predictive quality assurance in aerospace use case.

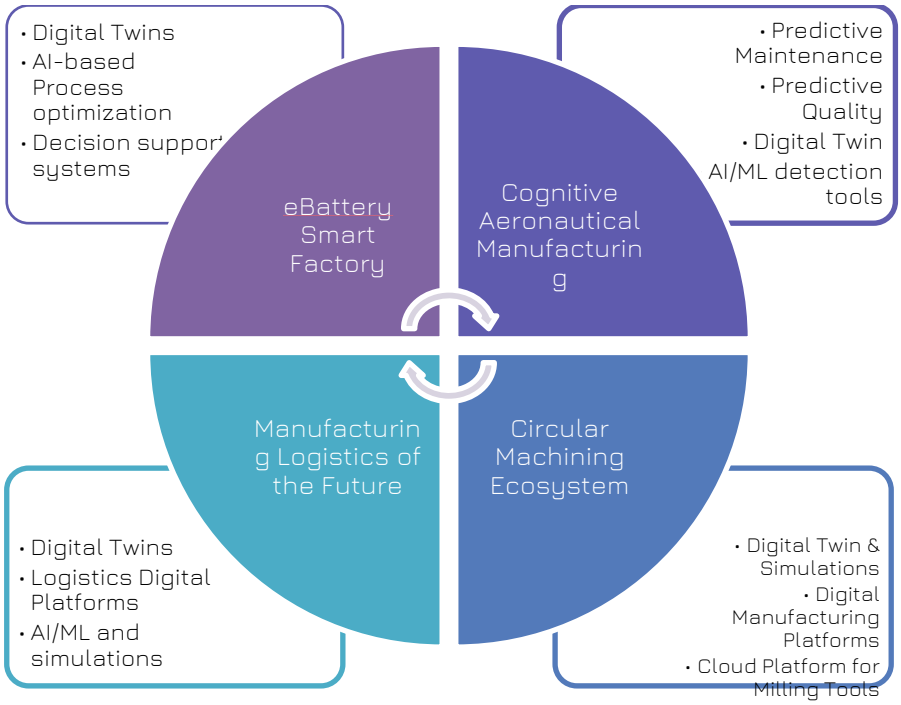


Figure 12: RE4DY use case concept and technologies

In the context of this analysis, we examine the key technological pillars of Industry 4.0 that have a direct connection to RE4DY developments and an established market in the manufacturing domain. More specifically under consideration to this point are the following pillars :

- Internet of Things (IoT): Utilizing sensors and interconnected devices for real-time data collection and exchange among machines, products, and systems. This data is instrumental in enhancing decision-making and automating processes.

- Big Data and Analytics: Recent advancements in big data analytics in manufacturing, optimizing production quality, equipment servicing, and energy savings. It involves the comprehensive evaluation and collection of data from various sources, including production equipment, systems, and organizational data.
- Artificial Intelligence and Machine Learning: Enabling machines and systems to learn from data, identify patterns, and make autonomous decisions. In Industry 4.0, AI is applied in predictive maintenance, quality control, and process automation.
- Cybersecurity: Given the heavy reliance on interconnected systems and data exchange in Industry 4.0, robust cybersecurity measures are essential for safeguarding sensitive data. Standard communication protocols and increased connectivity are key considerations.
- Cloud Computing: A fundamental component that enables the storage, sharing, and processing of data and applications across distributed networks. It plays a pivotal role in digital transformation.
- System Integration: Horizontal integration enhances networking among cyber-physical systems and enterprise systems, connecting devices and systems within all levels (shopfloor, manufacturing, supply chain). Vertical integration ensures that data is accessible across the value chain.
- Digital Twins / Simulation: Digital twins are virtual simulations of real-world products, machines, systems, or processes based on IoT sensor data. They empower businesses to analyze, understand, and enhance the maintenance and performance of products and industrial systems through accurate digital replicas.
- Augmented Reality (AR) and Virtual Reality (VR) : In the manufacturing industry, Augmented Reality and Virtual Reality technologies play a crucial role in enhancing various aspects of operations. These technologies contribute to identifying and mitigating potential threats, optimizing operational processes, aiding in design activities, facilitating employee training, and ultimately boosting safety by minimizing accidents.
- Autonomous Robots: Autonomous robots are machines designed to perform tasks or operations without direct human control. They rely on artificial intelligence, sensors, and programming to navigate and make decisions independently.
- Additive manufacturing: Additive manufacturing, often known as 3D printing, is a manufacturing process that builds objects layer by layer using digital 3D models. It involves adding material rather than subtracting it, as in traditional manufacturing. Additive manufacturing reduces production times and enhances

product durability. Furthermore, it enables developers to incorporate intricate designs and features without increasing costs.

Manufacturing data spaces, are designed to create a structured environment for collecting, managing, and sharing data within the manufacturing sector. They leverage a range of Industry 4.0 technologies as previously mentioned.

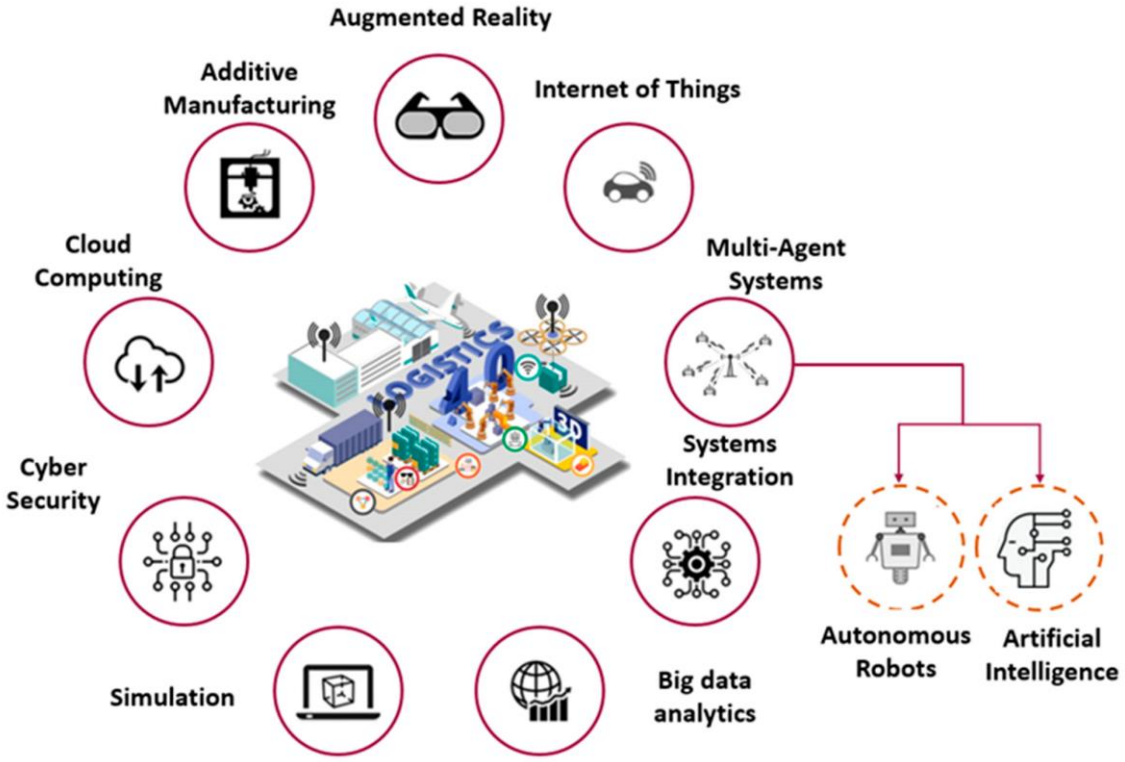


Figure 13: Industry 4.0 technological pillars

2.2.1 Digital Twins and simulations segment

The first definition of Digital Twin was introduced by NASA as "an integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its flying twin. It is ultra-realistic and may consider one or more important and interdependent vehicle systems. A digital twin is essentially a virtual replica of a physical entity, system, or process. This concept allows for the creation of a digital counterpart that accurately mimics the characteristics, behavior, and interactions of its real-world counterpart. Digital twins are a versatile technology applied in various industries such as manufacturing, healthcare, and infrastructure, with the primary goal of improving understanding, optimization, and decision-making. Over time, the potential applications of digital twin technology have expanded significantly, particularly due to its integration with Internet of Things IoT sensors. When combined with artificial intelligence (AI) and analytics, digital

twins empower engineers to conduct simulations and predictive modeling before the physical product or system is built.

The global digital twin market was valued at approximately 10 € billion in 2022 and is expected to experience a robust compound annual growth rate of 38.7% from 2023 to 2030. Based on end-user, the global market is segmented into manufacturing, agriculture, automotive and transport, energy and utilities, healthcare, and life sciences, residential and commercial, retail and consumer goods, aerospace, and telecommunication. The automotive and transport segment has a crucial role in the market and is poised for significant growth, with an estimated CAGR of 44.32%. This segment is expected to contribute to approximately 20% of the market's revenue. Increasing adoption of digital twin technology is being driven by forthcoming trends in the automotive industry, such as shared mobility, connected and autonomous vehicles, and connected transportation systems. In 2022, North America secured the largest market share, accounting for 35.14% of the market. Meanwhile, Asia Pacific is forecasted to have the highest CAGR of 40.4%, signifying substantial growth prospects in the region, while Europe is the third largest region in the global digital twin market & is projected to grow at a CAGR of 43.7%.

The digital twin market is characterized by fragmentation and includes key technology providers in the industrial sector including ABB, AVEVA Group, Dassault Systems, IBM, SAP, PTC, Siemens, General Electric, Hexagon AB, ANSYS, Microsoft, and others. These industry leaders are contributing to the advancement and proliferation of digital twin technology in various sectors, driving innovation in the domain.

Figure 14: Digital Twins market size [USD Billion]

Understanding market drivers is essential for stakeholders, businesses, and researchers looking to develop the full capabilities of digital twin technology. Below a set of drivers:

- Digital Twinning Technology expansion: There is a growing emphasis on digital twinning technology, driven by the increased development of digital twin technologies through cloud computing, the IoT, and other means. High-quality prototypes and performance improvements associated with digital twins are driving the market's growth.
- Expanded Applications: Digital twin technology is finding applications across various industries, leading to increased production and manufacturing efficiency. The deployment of IoT and computing services has improved internet connections, which, in turn, enhance performance, asset management, and process control, contributing to increased productivity and market growth.
- Predictive Maintenance: The use of digital twins for predictive maintenance is on the rise, allowing for more proactive and efficient management of assets, reducing cost, and optimizing operations.

On other hand, challenges can pose a barrier to the adoption and expansion of digital twin technology. Identifying and understanding these challenges is crucial for stakeholders looking to develop and implement digital twins[66,67]:

- Increased Implementation Cost: The advanced development of digital twin technologies involving IoT, cloud computing, and other components has raised the cost of digital twins. This cost increase might reduce the market's growth rate.
- Lack of Skill: Implementing digital twins requires individuals with specific skills to manage and optimize the technology. A lack of these skills can hinder the adoption and growth of digital twin solutions.
- Lack of Connectivity: Effective use of digital twin technology relies on a robust internet connection. If connectivity is lacking or unreliable, it can reduce the effectiveness of digital twins, leading to decreased production efficiency.
- Cybersecurity and Risks: With the increased use of cloud platforms and IoT in digital twin technology, concerns related to cybersecurity and other risks have arisen. These concerns can affect trust and adoption among potential users and impede market growth.

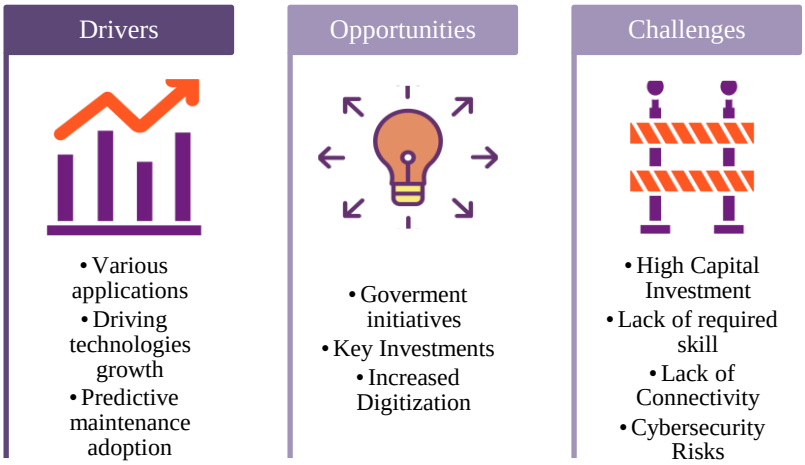


Figure 15: Digital Twins market, drivers, barriers, and opportunities

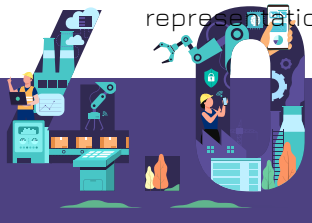
Furthermore, there are market factors that are worth mentioning, which can facilitate market growth, and the technology providers involved can leverage and capitalize to drive growth and innovation:

- Government Initiatives: Support and investments from governments and regulatory bodies to promote digital twin technologies and their applications in various industries.
- Investment from Key Players: Leading companies and industry players are increasing their investments in digital twin technologies, driving innovation and adoption.
- Increasing Digitalization: The ongoing digital transformation across industrial sectors is creating a demand for digital twin solutions to optimize processes, enhance productivity, and respond to changing market conditions.

The adoption of digital twins is transforming various industries, and more specific market information are represented below focusing on the project use cases and its ambitions towards digital twin utilization.

2.2.1.1 Digital Twins for production-logistics

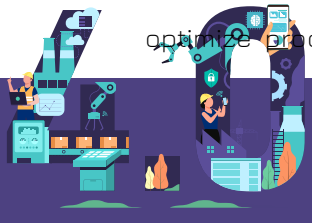
Logistics is entering a new era with Industry 4.0. Digital twins are just one technology that may be key to success in the future as digital transformation takes. In the field of intralogistics, digital twins play a pivotal role in enhancing warehouse efficiency. They enable the simulation, testing, and optimization of systems and processes within the warehouse environment, ensuring long-term reliability and effectiveness before they are tested into practice in the real world. The Mecalux Group utilizes the Automatic Warehouse Studio (AWS) software for its automated projects, which plays a crucial role in ensuring the success of their automated storage and retrieval systems (AS/RS). AWS offers a 3D virtual representation of the warehouse, allowing for detailed planning and simulation which



aligns with the goals of RE4DY use case . It permits the validation of the automated equipment's operation before it is implemented in the physical warehouse. This simulation software significantly reduces the time required for AS/RS implementation and ensures that the proposed solution aligns perfectly with the customer's logistics needs. This development aligns with the Auto Europa Volkswagen use case ambition to implement an automatic AS/RS Sequencing System for car glass assembly. In addition, AWS integrates with a SCADA (supervisory control and data acquisition) tool to provide real-time data from all machinery management software (PLCs) within the facility. This real-time monitoring allows logistics managers to proactively address any potential issues within the warehouse, enhancing efficiency and reliability. An illustrative example of AWS's effectiveness is its application in one of Europe's largest rack-supported buildings, constructed for Congelados Navarra in Fustiñana, Spain. The digital representation generated by AWS was instrumental in controlling and validating the proper functioning of the warehouse's equipment before the physical installation.

2.2.1.2 Digital Twins for aerospace

Many aerospace companies are increasingly adopting digital twins to minimize system downtime. Digital twins are particularly advantageous in aerospace, as they enable the connection between the physical modules and the utilization of artificial intelligence, big data analysis, and machine learning. Additionally, digital twins have the capability to identify and mitigate potential threats, contributing to improved safety and operational efficiency in the aerospace sector. The application of digital twins in the aerospace industry has yielded significant benefits, with notable examples. Rolls-Royce utilized digital twins to predict maintenance requirements for its engines. This proactive approach has led to a considerable reduction in engine downtime and improved reliability. By accurately forecasting maintenance needs, Rolls-Royce can optimize resource allocation and reduce unplanned downtime. Lufthansa Technik has leveraged digital twins to reduce aircraft maintenance costs significantly. By monitoring real-time data from its fleet and accurately predicting maintenance requirements, the company can perform maintenance activities when necessary, avoiding unnecessary or premature tasks. As a result, Lufthansa Technik has achieved a substantial reduction in maintenance costs, ensuring cost-effectiveness and maximizing the operational efficiency of its aircraft fleet. These examples highlight the impact of digital twins in the aerospace industry, from predictive maintenance to innovative design and cost reduction. In the RE4DY initiative, a key use case ambition is to attain near real-time predictive quality for distributed multi-plant aeronautical manufacturing processes. This is pursued through the development of a Manufacturing Digital Thread designed to facilitate efficient data sharing and consumption within a multi-Digital Twin environment. This approach aims to enhance collaboration, optimize processes, and enable predictive insights not only within the manufacturing



network but also across the extended value chain ecosystem. In alignment with the examples, the RE4DY use case is focusing on achieving reduction of non-conforming parts and reduction of the number of defects produced for the selected parts.

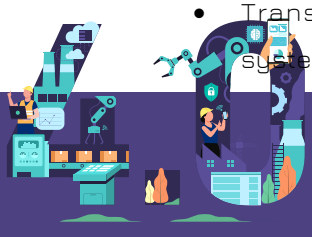
2.2.1.3 Digital Twins for machine tools

Digital twins are making a significant impact on the optimization of machine tool engineering processes. There are two very different application scenarios for digital twins in the lifecycle of machine tools: One is determined by the requirements of the machine builder, and involves application during the design, engineering, commissioning, maintenance, and servicing of machines. The second application scenario concerns the machine tool operation, particularly the creation and verification of reliable computer Numerical Control (CNC) programs. It is important to be aware of and understand these differences when digitalizing production and purchasing new machines. SIEMENS and DMG MORI have introduced a comprehensive digital twin for machine tool machining on Siemens Xcelerator. This solution, built on the Digital Native CNC Sinumerik One, encompasses the digital twin of the controller, the custom DMG MORI machine tool, and the workpiece. This aligns with the ambition of RE4DY to develop circular Digital Twin for machining process, including for key components and consumables as spindles, tools, consumables, providing full digital threads from manufacturing.

2.2.2 Predictive Maintenance segment

Predictive maintenance (PdM) is an evolution of condition-based monitoring, designed to optimize equipment performance and extend its lifespan by continuously assessing its real-time health. This is achieved by collecting data from sensors and utilizing advanced analytical tools, including machine learning (ML). Predictive maintenance enables the identification, detection, and proactive resolution of issues as they arise, as well as the prediction of potential future equipment conditions. Predictive maintenance technologies encompass nondestructive testing methods such as acoustic, corona detection, infrared imaging, oil analysis, sound level measurements, vibration analysis, and thermal imaging. These technologies facilitate the real-time collection of operational and equipment data through wireless sensor networks. Predictive maintenance solution providers leverage these data and employ machine learning techniques, such as classification or regression approaches, to pinpoint vulnerabilities in equipment. The architecture of predictive maintenance included four fundamental stages:

- Sensing and collecting data using predictive maintenance technologies (e.g., thermal imaging or vibration analysis).
- Transmitting this data in real-time across the network to a central business system.



- Applying intelligent technologies like Artificial Intelligence and Machine Learning analytics to derive the most relevant and useful insights from the data.
- Taking quick action based on these data-driven insights to establish maintenance and response protocols, involving both human and automated processes.

The global predictive maintenance market is experiencing significant growth, with a projected CAGR of 27.1% from 2023 to 2032. This market's size was estimated at €4.2 billion in 2022 and is expected to reach approximately €46.1 billion by 2032. The rapid expansion of predictive maintenance indicates the increasing importance of leveraging data and technology to optimize maintenance practices and reduce downtime across various industries.

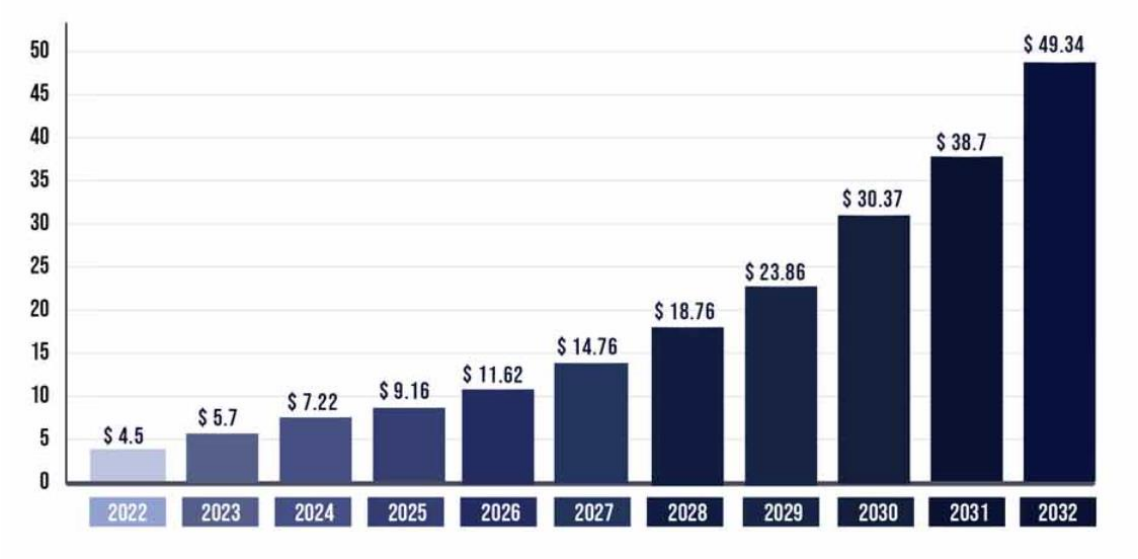


Figure 16: Predictive Maintenance market size (USD billions)

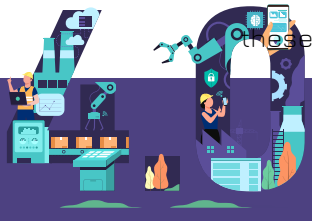
The European predictive maintenance market's value was estimated at €490.88 million in 2021, with projections to reach €34,823.24 million by 2029, showcasing a remarkable CAGR of 70.3% during this period. In terms of regional segmentation, North America currently leads the predictive maintenance market, primarily attributed to substantial investments made by companies in the sector and the presence of infrastructure in the region. Following, Europe is set to secure the second-highest position in the market and is expected to have a high CAGR until 2029. In the realm of global market growth, Asia Pacific is anticipated to emerge as the fastest-growing region in terms of CAGR. Meanwhile, the Middle East and Africa are projected to experience a steady growth rate in the predictive maintenance market. The manufacturing sector stands out as the most dominant vertical for the application of predictive maintenance systems, contributing to nearly 30% of the market share. Manufacturing, being a well-established global sector, takes the lead in maintenance requirements, despite a significant market presence in the global defense

sector. In terms of deployment methods, the on-premises mode takes the top position, accounting for approximately 68% of the market share. This dominance can be attributed to the ease of implementing systems within a plant setup and lower capital expenditure associated with this model. However, cloud deployment is expected to have rapid growth in the future due to the increased adoption of cloud-based technologies across various sectors. An indicator of this trend is the increase in cloud-based data centers, which substantially the past years. Several key companies are actively operating in the predictive maintenance market, including Oracle, SAP, Altair, General Electric, IBM, Siemens AG, Banner Engineering, and Schneider Electric SE. In the following section, we will explore market drivers and their roles in shaping the landscape of predictive maintenance market.

- Investment in predictive maintenance initiatives generates a tangible return on investment (ROI). For instance, predictive maintenance users reported metrics such as 2-6% increased availability, 5-10% inventory cost reduction, and 10-40% reduction in reactive maintenance.
- The integration of artificial intelligence and machine learning has created growth opportunities for the predictive maintenance industry. The reports indicate that AI has the capacity to boost profit margins by 38%. Additionally, by the year 2035, it is projected to drive growth in about 16 different industries, contributing approximately €2.6 billion.
- Emergence of Big Data Analytics: The rise in the emergence of big data analytics across the EU region accelerate the market growth. Numerous companies are focusing on combining internal data and external data sources for acquiring new ways to assist in expanding the business.
- Increasing Maintenance Efficiency: The increased adoption of predictive maintenance programs to prevent unplanned reactive maintenance further influences the market. These services allow the maintenance frequency to be as low as possible to prevent unplanned maintenance and reducing costs.
- Real-time Condition Monitoring: The need for real-time condition monitoring is a significant driver for predictive maintenance. It enables companies to identify issues promptly and take corrective actions before they escalate, reducing downtime and maintenance costs.

While predictive maintenance offers many benefits, there are challenges need to be addressed for its adoption. Stakeholders must consider these factors when planning their predictive maintenance initiatives.

- Maintenance and Upgradation Requirements: Predictive maintenance systems require regular maintenance and updates to remain effective. This can be costly and time-consuming for companies, potentially discouraging some from adopting these technologies.



- Lack of Skilled Workforce: Implementing and maintaining predictive maintenance systems often requires a skilled workforce that understands AI-based technologies. The shortage of skilled employees in this field can be a challenge for many organizations.
- Data Security Concerns: With the increasing reliance on data for predictive maintenance, concerns about data security become a significant hurdle. Companies need to ensure that sensitive operational data is protected from cyber threats and breaches.
- Data Ownership and Privacy: The ownership and privacy of data collected through predictive maintenance systems can be an issue. Companies need to navigate legal and ethical considerations.
- High Capital Expenditure: The implementation of predictive maintenance often involves a significant capital expenditure. This initial investment can act as a limiting factor for smaller companies or those with budget constraints, making it challenging for them to invest in these systems.

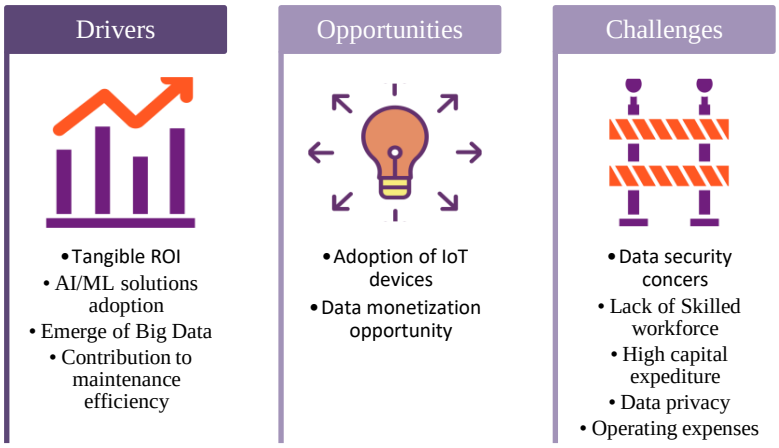


Figure 17: Predictive maintenance market, drivers, barriers, and opportunities

- Adoption of IoT Devices: The increasing adoption of IoT devices in predictive maintenance allows for remote and real-time execution of maintenance tasks. These devices collect data from machines and equipment, transmitting it to cloud-based platforms.
- Data Monetization: Beyond maintenance insights, companies can explore opportunities to monetize the data collected by predictive maintenance solutions by offering valuable analytics and insights to third parties.

As AI and IoT continue to evolve and become more deeply integrated into industrial processes, the predictive maintenance market is likely to expand further, offering improved efficiency and cost savings for businesses across various sectors.

2.2.3 Federated Learning segment

Federated learning is an innovative machine learning paradigm designed to facilitate model training across numerous decentralized edge devices, including smartphones, IoT devices, and local servers. This approach prioritizes data privacy and security, making it particularly advantageous in scenarios where safeguarding sensitive information is crucial. As of 2023, the Federated Learning Market is valued at €122.1 million, and it is predicted to experience substantial growth over the next decade. The forecast indicates that the market is expected to reach a value of €285.4 million by the year 2032. This projected growth represents an estimated CAGR of 10.2% from 2022 to 2032.

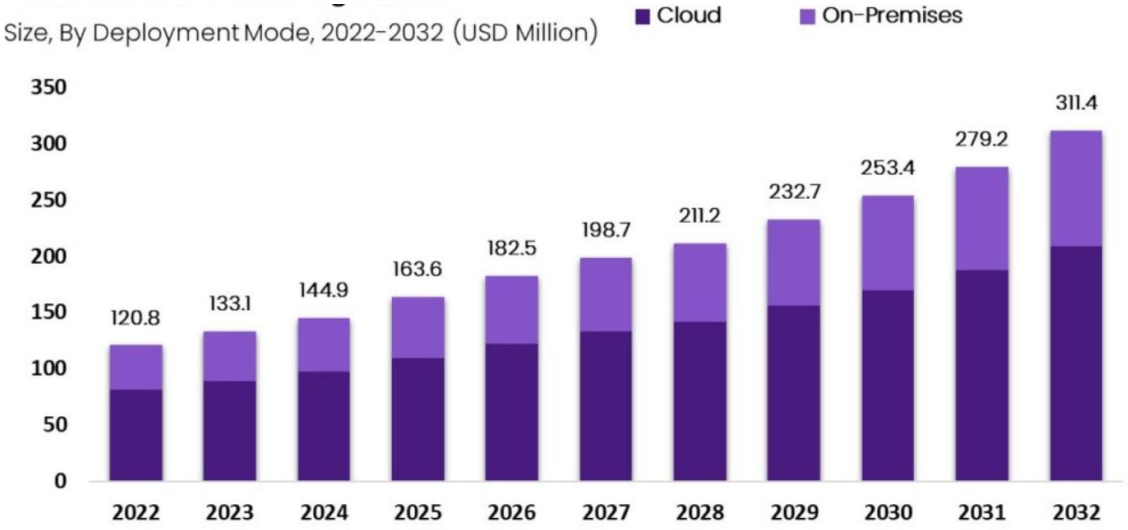
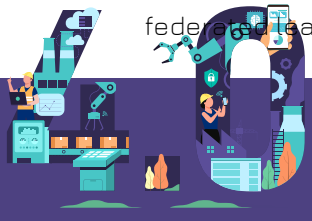


Figure 18: Global Federated Learning Market Size

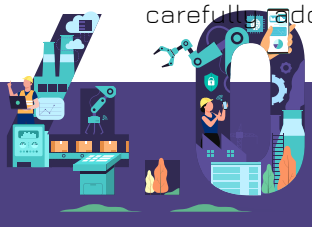
In terms of vertical segmentation, the market for federated learning is categorized into various sectors, including IT & Telecommunication, Banking and Financial Services, Healthcare & Life Sciences, Energy & Utilities, Manufacturing, Automotive & Transportation, Retail & Ecommerce, and Others. Notably, the healthcare and life sciences category held the largest revenue share in 2021. However, during the projected period, the automotive and transportation vertical is expected to experience the highest CAGR, while energy and utilities and manufacturing can utilize the technology for predictive maintenance and energy optimization. The automotive and transportation sector presents unique challenges and opportunities for federated learning, especially in the context of the complex technology behind autonomous vehicles. The systems in autonomous vehicles rely on a diverse set of technologies, including observation, forecasting, monitoring, localization, modeling, interfaces utilizing public clouds, and data management. Nvidia, the well-known technology company renowned for its expertise in graphics processing units (GPUs) designed for gaming and artificial intelligence, has extended its reach into the federated learning market. The company provides solutions that enable the processing of



data without centralized aggregation, particularly focusing on training AI models with distributed data on edge devices. This approach ensures enhanced privacy and reduces the necessity to transmit sensitive data. Similarly, IBM offers a range of solutions designed to facilitate privacy-preserving collaboration and machine learning across multiple entities. Their federated learning platform ensures secure training and aggregation of AI models from distributed data sources. Google has been at the forefront of developing federated learning solutions. Google's federated learning framework allows collaborative model training without centralized data storage, emphasizing data security and privacy. Leveraging its vast resources, research expertise, and widespread adoption of its products, Google has achieved significant growth and market share in the federated learning solution market. In the following section we present factors propelling the market growth:

- Growing Need for Improved Data Protection and Privacy: The increasing demand for enhanced data protection and privacy is a key driver for the advancement of the federated learning solutions market. The ability of these solutions to retain data on devices aids organizations in leveraging machine learning models while ensuring privacy.
- Real-time Data Adaptation for Conversions: The requirement to adapt data in real-time for optimizing conversions automatically is driving the market forward. Federated learning solutions enable organizations to provide predictive features on smart devices without compromising consumer experience or revealing private information.
- Collaborative Quality Control and Maintenance: The manufacturing sector can leverage federated learning for collaborative quality control and predictive maintenance. By training machine learning models on diverse manufacturing devices, the industry can enhance product quality, reduce downtime, and optimize maintenance schedules collaboratively.
- Adoption of predictive and prescriptive analytics. Predictive analytics are employed to assess the likelihood of specific events occurring in the future, while prescriptive analytics offer actionable solutions in the event of such occurrences. The broad applications of predictive and prescriptive analytics present significant growth opportunities within the industry.
- IoT Device Proliferation: Federated learning is well-positioned to capitalize on the growing number of IoT devices. As the IoT ecosystem expands, federated learning enables local model training on these devices, fostering real-time and context-aware AI applications.

Although numerous advantages are presented, there are challenges that must be carefully addressed for its successful adoption. Stakeholders involved in federated



learning initiatives need to take these factors into consideration to ensure effective implementation:

- Integration Challenges into Existing Workflows: Many businesses face challenges integrating machine learning into existing workflows due to a shortage of trained personnel, particularly IT specialists. The novel concept of federated learning systems poses difficulty for personnel to grasp and implement, leading to recruitment challenges of skilled experts.
- Complexity of Federated Learning Systems: The complexity of federated learning systems becomes a barrier as organizations struggle to incorporate projects involving advanced methodologies like machine learning.
- Model Convergence time: Another challenge in federated learning is the convergence time of models. Federated learning models often take longer to converge compared to locally trained models. Various factors such as network problems, irregular updates, and different application use periods contribute to extended convergence times and reduced reliability. The use of more devices in training can further increase the unpredictability of the model.

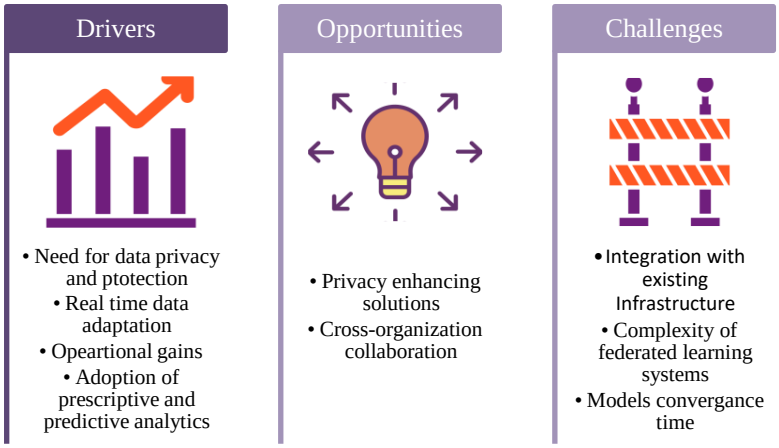


Figure 19: Federated learning market, barriers, and opportunities

Additionally, there exist several factors that not only present lucrative opportunities but also foster the expansion of the federated learning solutions market:

- Cross-organization Collaboration: Key players are forming partnerships to develop industry-wide standards, protocols, and frameworks (ECN-s/2805.4 standard for edge collaboration protocols for Federated Learning, ISO/IEC 27001, ONNX -Open Neural Network Exchange-) for federated learnings. Companies can develop platforms that facilitate collaborative model training across industries.
- Privacy-Enhancing Solutions: With increasing concerns about data privacy, federated learning provides an opportunity to offer privacy-enhancing solutions. Companies can market federated learning as a method that allows machine

learning model training without exposing raw data, addressing privacy regulations, and building trust among users.

2.2.4 Industrial IoT platform segment

The IoT represents a vast network or interconnected networks that utilize standard Internet Protocol (IP) technologies. Within the expansive realm of IoT, the Industrial Internet of Things (IIoT) emerges as a distinct subset. In the context of IIoT, these connections are predominantly geared towards the production of tangible goods for the market and the maintenance of the physical assets involved in the production process. Thus, IIoT plays a specialized role within the broader landscape of IoT, focusing on the integration of digital technologies into industrial processes to enhance efficiency, productivity, and asset management. IoT platforms, often referred to as Application Enablement Platforms (AEPs), serve as a crucial form of middleware positioned between the layers of IoT devices and gateways on one side, and the applications they enable on the other. These platforms play a pivotal role in seamlessly integrating a variety of commercial sensors and actuators, providing a unified framework for managing and extracting insights from the diverse range of connected devices in the Internet of Things ecosystem.

As of 2022, the global Industrial IoT market was estimated to be €293.1 billion. Projections indicate significant growth, with expectations for the market to reach approximately €1,426.89 billion by 2032. This anticipated expansion reflects a CAGR of 17.2% during the forecast period from 2023 to 2032. The robust growth forecast underscores the increasing adoption and integration of industrial IoT solutions across various sectors, indicating a substantial market trajectory over the coming years.

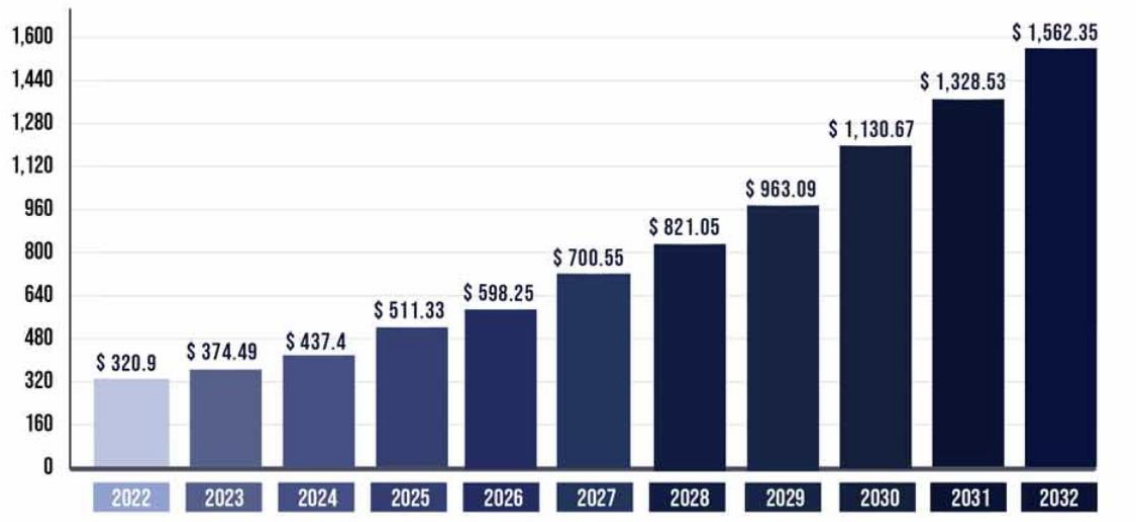
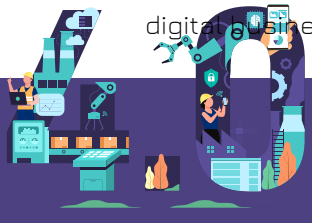


Figure 20: Industrial IoT market size

The manufacturing segment emerged as the dominant force in the Industrial IoT market in 2022. This is attributed to the widespread adoption of IoT solutions and digital manufacturing technologies across diverse manufacturing facilities, reflecting the industry's commitment to enhancing operational efficiency. The logistics and transport segment experienced the highest growth rate in the Industrial IoT market in 2022. This growth is propelled by the increasing emphasis on adopting smart transportation and asset management by logistics and transport service providers. The IIoT market is experiencing a consistent uptrend in IoT adoption, driven by various factors such as advancements in 5G and wireless technologies and the widespread use of Wi-Fi connectivity for machine sensors in industrial settings. Furthermore, organizations are leveraging this technology to employ advanced analytics and methodologies like Machine Learning and Artificial Intelligence. These tools enable the delivery of prescriptive and predictive analytical solutions, opening new opportunities for the sector. The continuous learning capabilities inherent in ML and AI, characterized by uninterrupted processes without downtime, contribute to the increasing demand for these technologies in the IIoT market. This heightened demand is a key driver propelling market growth throughout the forecast period. North America, particularly the U.S., held a dominant position in the Industrial IoT market in 2022. The U.S. accounted for a substantial share, driven by increased spending on IoT, with the U.S. investing approximately €421 billion in 2021. The presence of a significant number of well-established market players in North America further boosts segmental growth. Additionally, the emergence of numerous new players in the industrial IoT space creates lucrative opportunities for market expansion. In the European IoT market, solutions are driving accelerated growth, with the UK, Germany, and the Netherlands leading the adoption of IoT technologies. Various sectors in Europe, including health, manufacturing, and agriculture, are embracing IoT adoption, contributing to market expansion. In October 2020, Cognizant acquired Bright Wolf, a technology service provider specializing in custom IoT solutions. This acquisition was a key step in establishing a new Cognizant IoT innovation lab. Bright Wolf's expertise in industrial IoT deployments complemented Cognizant's proficiency in foundational IoT technologies. The collaboration has enhanced the operational efficiency, competitive advantage, and resilience of Cognizant's clients. In December 2021, Silicon Labs introduced its Custom Part Manufacturing Service, enabling makers to customize Silicon Labs hardware directly at the factory. Silicon Labs' hardware portfolio includes wireless System-on-Chips (SoCs), modules, and Microcontroller Units (MCUs). This customization service allows customers to personalize their hardware, providing a traceable footprint throughout the entire journey of the chip. In September 2022, Siemens launched "Siemens Xcelerator". This initiative represents a comprehensive and curated range of digital and Internet of Things (IoT)-enabled offerings. Siemens Xcelerator is designed to create an open ecosystem for digital business, incorporating solutions from Siemens as well as accredited third parties.



The Siemens Xcelerator ecosystem consists of a carefully selected portfolio that includes software, IoT-enabled hardware, and digital services. This portfolio adheres to essential design principles, emphasizing interoperability, flexibility, openness, and the as-a-service model. These strategic moves and innovations highlight the dynamic landscape of the technology industry, with a focus on advancing AI computing, IoT solutions, and customizable hardware offerings. Some factors driving the market growth are presented below:

- Rising Adoption of AI and ML: The global industrial IoT market is experiencing significant growth due to the increasing adoption of AI and ML across various industries. Sectors such as manufacturing, energy, and oil & gas are leveraging AI and ML technologies to enhance efficiency, automate service delivery processes, and stay competitive in the market. This trend of widespread AI and ML adoption acts as a major driver for the market's growth.
- Surge in Sensors and Distributed Control Systems: The implementation of sensors and Distributed Control Systems (DCS) is witnessing a surge in various business operations. These technologies contribute to the control and automation of work processes, playing a crucial role in managing industrial processes. The increasing demand for sensors and DCS in business operations is a key driver for the global industrial IoT market, promoting efficiency and automation in various industries.
- Growing Need for Real-time Data Solutions: The global industrial IoT market is propelled by a growing need for real-time data solutions and services. The requirement for electronic devices, particularly IoT devices, is on the rise to support real-time data analysis in business operations. The increasing demand for real-time solutions, driven by the usage of IoT devices, is a significant driver contributing to market growth.

However, the widespread adoption of IIoT technologies faces significant barriers that impede seamless integration and realization of its full potential. Addressing these challenges is essential:

- Lack of Qualified Workforce: Workforce skills, higher education requirements, and special qualifications are crucial for dealing with Industry 4.0 (I4.0) technologies. The successful integration of I4.0 technologies relies on a multidisciplinary workforce with highly developed soft and hard skills.
- Security, Safety, and Privacy Concerns: Cyber-attacks are anticipated to be a rising issue due to the data generated and distributed among companies by Cyber-Physical Systems (CPS) and IoT devices. Issues include identification verification, authorization procedures and protocols, privacy, and system access.

Ensuring security, safety, and privacy in the interconnected landscape is a significant challenge.

- Lack of Digital Strategy: There is an increasing need for the development and deployment of digital strategies that consider both vertical and horizontal aspects of the value chain. The digital strategy must address integration with various IT systems, emphasizing compatibility and interoperability as key aspects.
- Integration into Legacy Systems: Difficulties in integrating IIoT solutions with existing operational technology and IT systems remain a major adoption barrier. Challenges arise in porting data across different formats, retrofitting IIoT technologies into legacy equipment like Programmable Logic Controllers (PLCs), and integrating collected data into existing IT and enterprise management platforms. Retrofitting without complex and error-prone modifications is a key challenge in this context.

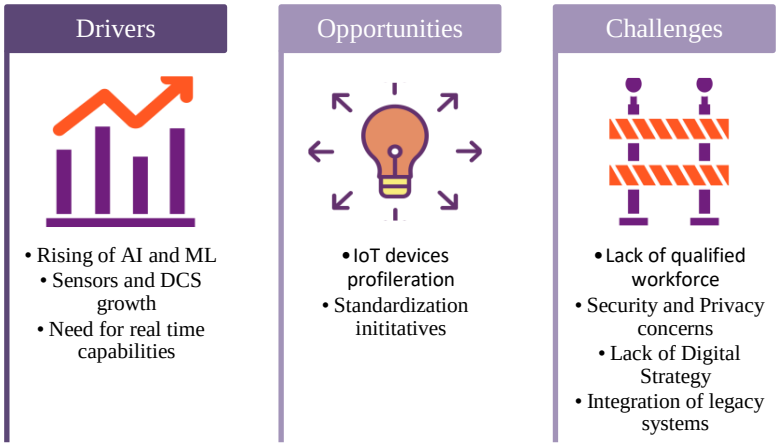


Figure 21: IIOT market, drivers, barriers, and opportunities

The dynamic markets offer opportunities for businesses and industries to flourish within the domain of emerging technologies and digital transformation. Utilizing these opportunities is essential to maintaining competitiveness in this ever-evolving landscape:

- AI and IoT-integrated system: The adoption of AI and IoT technologies in the manufacturing industry has accelerated since the start of Industry 4.0. Production process optimization, early warnings, quality control, and machine failure prediction are all possible
- Adoption of Digital Twin: The incorporation of Digital Twin technology, along with the IIoT, marks a significant advancement in manufacturing. The creation and utilization of digital twins enhance the manufacturing process by creating virtual replicas of physical systems, enabling simulation, analysis, and optimization.
- Technological Advancements in 5G IoT Solutions: The evolution of 5G IoT solutions provides manufacturers with high-speed, low-latency connectivity,

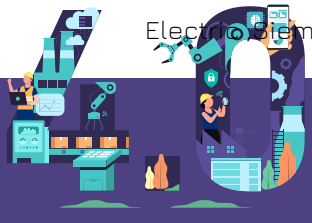
opening new possibilities for real-time data exchange, remote monitoring, and control.

These opportunities underscore the transformative potential of AI and IoT in the manufacturing industry, fostering innovation and efficiency across various aspects of the production lifecycle.

2.2.5 Industrial Cybersecurity segment

Industrial Cybersecurity refers to the measures and practices implemented to secure the systems and networks used in industrial settings from cyber threats. Industries such as manufacturing, energy, utilities, and transportation rely heavily on interconnected systems, industrial control systems (ICS), and the IIoTfor efficient operations. As these industries become more digitized and interconnected, they also become more susceptible to cyberattacks Cybersecurity is a comprehensive field encompassing technologies, processes, and methods designed to safeguard computer systems, data, and networks from various forms of attacks.

The global Industrial Cybersecurity Market, valued at €22.91 billion in 2022, is projected to reach €44.65 billion by 2030, indicating a CAGR of 8.54% from 2023 to 2030. The market is categorized by type into network security, endpoint security, cloud security, application security, and others. The network security segment took the lead with a market value of €6.28 billion in 2022. This dominance can be attributed to the increased adoption of network security devices and the growing demand to secure various enterprise networks. In terms of end-users, the global industrial cybersecurity market is categorized into industrial manufacturing, energy & utilities, transportation & logistics, and other sectors. The industrial manufacturing segment is anticipated to hold the largest market share in 2023, driven by the escalating demand for real-time security monitoring among manufacturers, a rise in cybersecurity incidents, and the growing utilization of smart devices. Geographically, the market is segmented into North America, Europe, Asia-Pacific, Latin America, and the Middle East & Africa. North America is projected to dominate the global industrial cybersecurity market in 2023, primarily due to increasing government initiatives, the proliferation of advanced technologies in the region, and a rise in cyber-attacks targeting the industrial sector. The global industrial cybersecurity market exhibits a fragmented nature, and prominent players are adopting various key business strategies to enhance their market presence. These strategies include partnerships, mergers and acquisitions, product innovations, and joint ventures, aiming to expand their product portfolios and increase market shares across different regions. Major players in the industrial cybersecurity market include ABS Group of Companies, Inc., Cisco Systems, Inc., Fortinet, Inc., Honeywell International Inc., Microsoft, Rockwell Automation, Schneider Electric, Siemens ,Thales and IBM. Comprehending the factors that drive market growth is



crucial for stakeholders, businesses, and researchers aiming to unlock the complete potential of the domain. The following are key drivers :

- Increasing Government and Private Investments: The industrial cybersecurity market is witnessing growth due to rising investments from both government and private sectors. Dragos, a cybersecurity company for OT environments, announced in September 2023 the successful completion of a Series D extension funding round, raising €72 million. In the wider cybersecurity domain, In the first half of 2023, 155 cybersecurity companies secured new funding, totaling €4.336 billion. This significant injection of capital aligns with the growing awareness and acknowledgment from governments and infrastructure providers worldwide about the pivotal importance of industrial cybersecurity. The financial support is crucial for the development and implementation of robust cybersecurity measures in industrial settings.
- Integration of AI-Powered Industrial Robots: The emergence of AI-powered industrial robots has become a significant driver for industrial cybersecurity. The integration of AI into industrial robots enables automation of complex and repetitive tasks, leading to enhanced productivity and efficiency in industrial operations. However, this integration also brings forth the need for effective cybersecurity measures to protect against potential cyber-attacks and data breaches.

The extensive adoption of these solutions is confronted by barriers that hinder smooth integration and the realization of its complete potential. Overcoming these challenges is imperative for unlocking the value and the vital benefits of Cybersecure organizations:

- Lack of Adequate resources and Governance: The development of robust industrial cybersecurity solutions requires significant resources and effective governance. Many industrial organizations face challenges in securing the necessary resources and implementing governance structures essential for the development of comprehensive cybersecurity solutions.
- Industrial Cybersecurity Issues and Limited Availability of Experienced Professionals: High costs and the scarcity of experienced cybersecurity professionals pose significant challenges for industrial organizations. Addressing these concerns involves a comprehensive approach, including the establishment of specific training programs, the adoption of best practices for system security, and the implementation of a zero-trust architectural model. These measures are crucial for enhancing cybersecurity and mitigating the potentially severe consequences of cyber breaches.

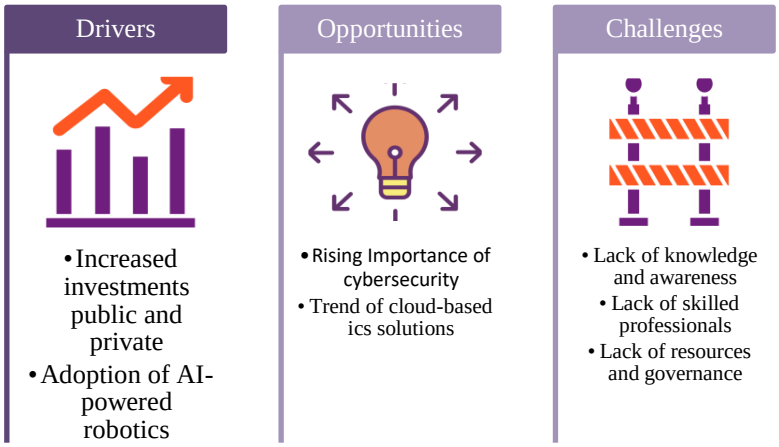


Figure 22: Industrial Cybersecurity market, drivers, barriers, and opportunities

The dynamic market presents opportunities for businesses and industries to thrive in the realm of emerging technologies and digital transformation. Seizing and leveraging these opportunities is essential for maintaining competitiveness in this ever-evolving landscape.

- Rising importance of cloud based industrial cybersecurity services: The increasing adoption of cloud-based industrial cybersecurity services aligns with the broader trend of digital transformation in industries. As organizations embrace the benefits of the cloud, they are leveraging these services to fortify their cybersecurity posture and ensure the resilience of their industrial systems against evolving cyber threats.
- Cloud-Based ICS-as-a-Service: Industrial plants are increasingly transitioning to cloud-based ICS solutions offered as services. This shift provides flexibility, scalability, and remote accessibility for managing and monitoring control systems. Cloud-based ICS services play a crucial role in modernizing industrial infrastructure.

3 Exploitation Strategy

The overarching aim of the RE4DY project is to showcase the collaborative capacity of the European industry in developing innovative data-driven digital value networks. These networks are designed to maintain competitive advantages by ensuring digital continuity and establishing sovereign data spaces throughout all stages of product and process lifecycles. A central pillar of the project is the introduction of the "Data as a Product" concept, which seeks to streamline the implementation of digital continuity across various components such as digital threads, data spaces, digital twin workflows, and AI/ML/Data pipelines. The Consortium, comprising diverse stakeholders, will actively participate in research, development, validation, and implementation of the Digital 4.0 continuity services. The exploitation objective of the project involves designing a strategy to capitalize on the outcomes of RE4DY. The exploitation objective within this context is to provide a detailed strategy for leveraging the RE4DY outcomes, providing value creation opportunities thereby reducing obstacles for manufacturing stakeholders manufacturing and industries to adopt reliable data asset management toolkit and AI lifecycle management services.

3.1 Exploitation plan & objectives

The exploitation efforts within Work Package 6 (WP6) of the RE4DY project, are specifically outlined in Task 6.3 “Impact analysis & commercial exploitation”, aiming to achieve several objectives. The Exploitation Objectives linked to Task 6.3 will focus on specific goals aimed at maximizing the utilization and impact of the outcomes associated with the technical developments and ultimately develop a business model and exploitation plan to sustain RE4DY outcomes. A work plan has been outlined (Figure 24) to effectively execute the exploitation strategy of RE4DY and facilitate the exploitation objectives. This plan considers the following key pillars of work:

- Commercial Exploitation of Results: Activities focused on leveraging commercially viable outcomes of the project result and translate research findings into marketable services or products.
- Non-Commercial Exploitation of Results: Utilize non-commercially oriented results to deliver impact to a diverse range of stakeholders and communities and explore ways to apply these results without a primary emphasis on commercial gain.
- Joint Exploitation routes: Identify synergies within the consortium for shared utilization of the results to maximize impact and foster collaboration.
- Intellectual Property (IP) Strategy: Define an intellectual property strategy to protect key innovations and technologies developed within RE4DY, considering

whether to patent, copyright, or use other forms of protection for both individual and joint exploitation efforts.

- Business model development: Create a strong business case that outlines how RE4DY will create, deliver, and capture value, considering elements such as revenue streams, cost structures and pricing strategies to ensure long term sustainability.
- Roadmap to TRL9 and commercialization: Clearly communicate the financial requirements and resources needed for sustaining and developing further RE4DY developments. A research commercialization roadmap is a strategic tool that outlines the steps and actions to leverage the research outcomes for practical applications, and impact creation. The plan will support the consortium to translate the research finding and developments to tangible services, products, and innovative findings. In other words, it represents the research to market journey.

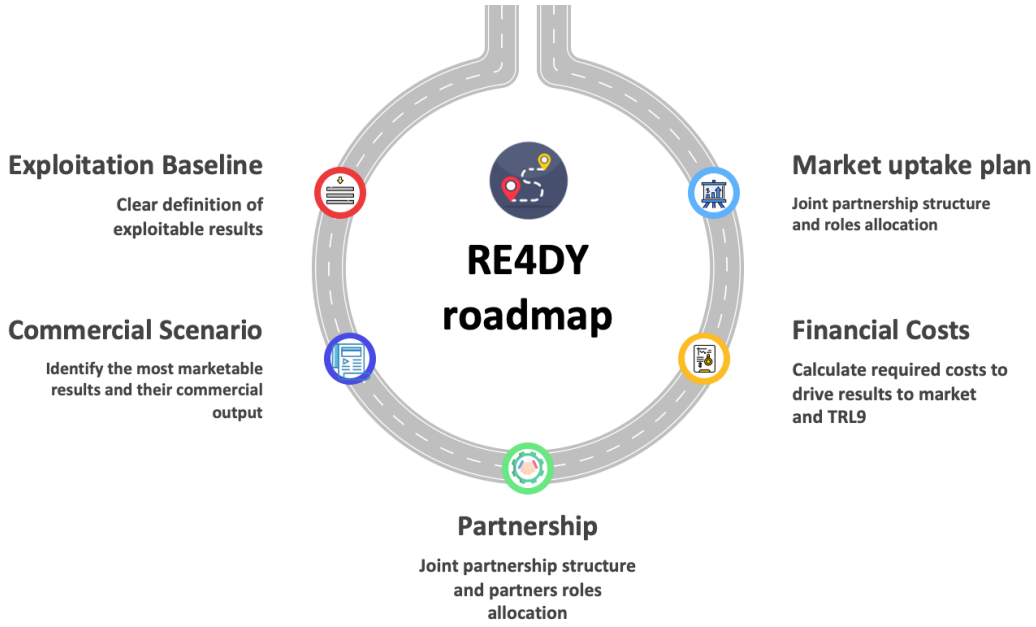


Figure 23: RE4DY commercialization roadmap

The overall scope is to ensure that the project's outcomes will deliver widespread benefits, either in terms of commercial offerings or contributions to society, academia, research organizations, open-source communities, and other audiences.

The work plan is organized into three phases, carefully structured to efficiently address all the tasks mentioned above in a comprehensive way.

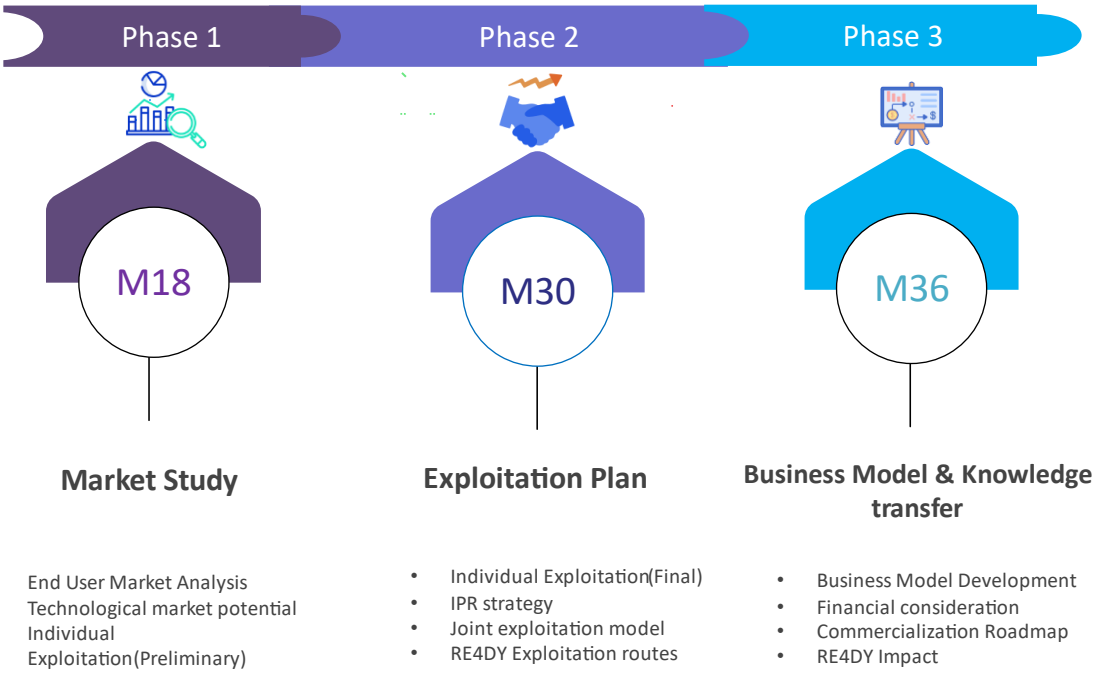


Figure 24: RE4DY Exploitation work plan

To further elaborate on the work plan:

Phase 1: Market Study: In this initial phase, the strategy focuses on conducting a market study to lay the foundation for strategic decision-making. The key activities include:

- Conducting an in-depth analysis of the market and external environmental factors to inform the exploitation strategy and gain insights into market trends, demands and challenges.
- Evaluate the technological landscape assessment to understand the potential and risk associated with the technologies addressed.
- A preliminary identification of the exploitable results and its characteristics and understanding the relevance to the target markets.

Phase 2: Exploitation plan: This phase includes the cultivation of the exploitation strategy and has a vital role in translating project outcomes into tangible scenarios including:

- Conducting a detailed analysis of the individual exploitable results, defining its attributes and future application.
- Creating a robust Intellectual Property Rights (IPR) Strategy to protect the results for post-project exploitation and utilization.
- Identify synergies for Joint Exploitation Scenarios of RE4DY results with clear ownership and impact delivery.

- Clearly defining the routes through which the project outcomes will be exploited, and outline the specific, channels, and methods that will be used.

Phase 3: Business model and knowledge transfer: In this last phase the efforts will focus on construing the business case for the project and facilitating knowledge transfer key activities within this phase include:

- The business model development.
- Extensive analysis on costs and resources associated with the further development of the project results, evaluating the financial feasibility of the exploitation strategy.
- Development of the commercialization roadmap to bring the results to the market.
- Communicating the significance of RE4DY's contributions and outline the means through which the result will reach the market and the targeted audiences.

This phased approach ensures a systematic and strategic progression towards the exploitation objectives, supporting both commercial and non-commercial utilization of project outcomes. By following this plan also, the aim is to deliver an exploitation model which will maximize the impact of RE4DY.

3.2Exploitation methodology

To achieve the objectives detailed above, CORE will leverage recognized methodologies and tools that align with RE4DY characteristics and support the Consortium's active involvement towards a strategic exploitation plan with strong partnerships and a clear path towards market penetration. The chosen methodology and tools will facilitate the process from the conceptualization RE4DY concept to the generation of tangible results and ultimately the commercialization of these results.

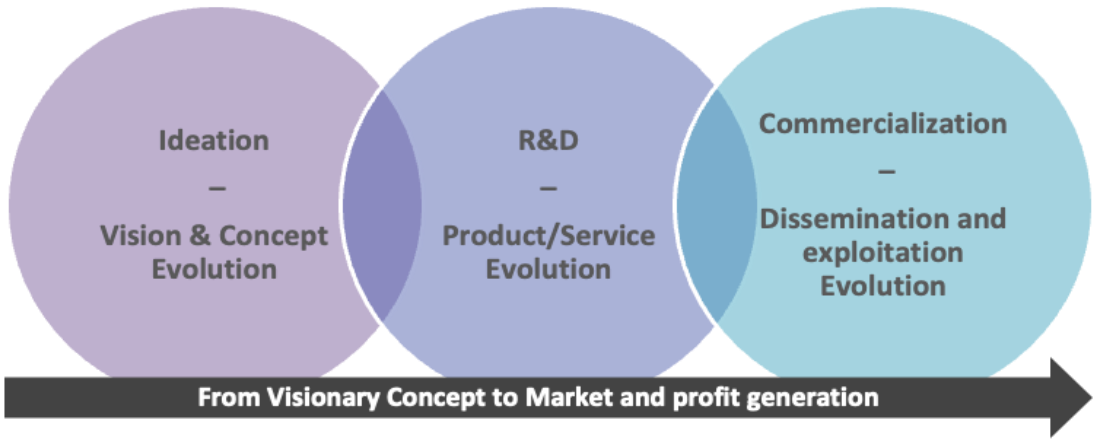


Figure 25: Research results commercialization concept

The tools and methods that will be utilized for Task 6.3 are:

- Market Analysis: Leverage market research tools to gather insights into market trends, barriers, and potential competitors. This information is vital for designing effective commercialization plans.
- External Environmental Analysis tools: Considering external factors influencing exploitation.
- Data gathering tools: Facilitate the exploitation of project outcomes by providing standardized tools and templates for information gathering.
- Workshops: Conduct workshops that bring together the consortium for a collaborative approach.
- Surveys / questionnaires: Collecting structured and quantitative data to gain insights, opinions, and feedback from targeted stakeholders.
- Value Network Tool: Explore and design the relations and the value exchange between RE4DY different stakeholders.
- Business Model Canvas: Employ the Business Model Canvas to visually represent and collaborate on the project's business model. This tool helps in defining key elements such as value proposition, customer segments, and revenue streams.
- Cost-benefit analysis: Conduct a detailed cost-benefit analysis to evaluate the financial potential or risks of the exploitation strategies.

In summary, CORE's strategic use of these tools and methodologies will demonstrate a holistic and collaborative effort to support RE4DY project towards its goals. The emphasis on active Consortium involvement, strong partnerships, and a clear path to market penetration positions the project for success in the dynamic landscape of digital industry.

4 Exploitable Results

The initial step on the path of exploitation involves the identification and definition of Individual Exploitable Results contributed by each partner. This process lays the foundation for the compilation of Key Exploitable Results (KERs) within the RE4DY context. In a nutshell, aKER is an identified main interesting result, which has been selected and prioritized due to its high potential to be "exploited" – meaning to make use and derive benefits- downstream the value chain of a product, process or solution, or act as an important input to policy, further research, or education. The exploitation of project results and their utilization can follow diverse routes. The direct routes provide straightforward means of leveraging the project results, while the indirect routes offer more sophisticated approaches. In the context of RE4DY, we have a strong presence of both direct and indirect results, showcasing the multifaced approach of the project, ranging from middleware and software services to frameworks and methodologies to support further research. These results are further elaborated in the next section.

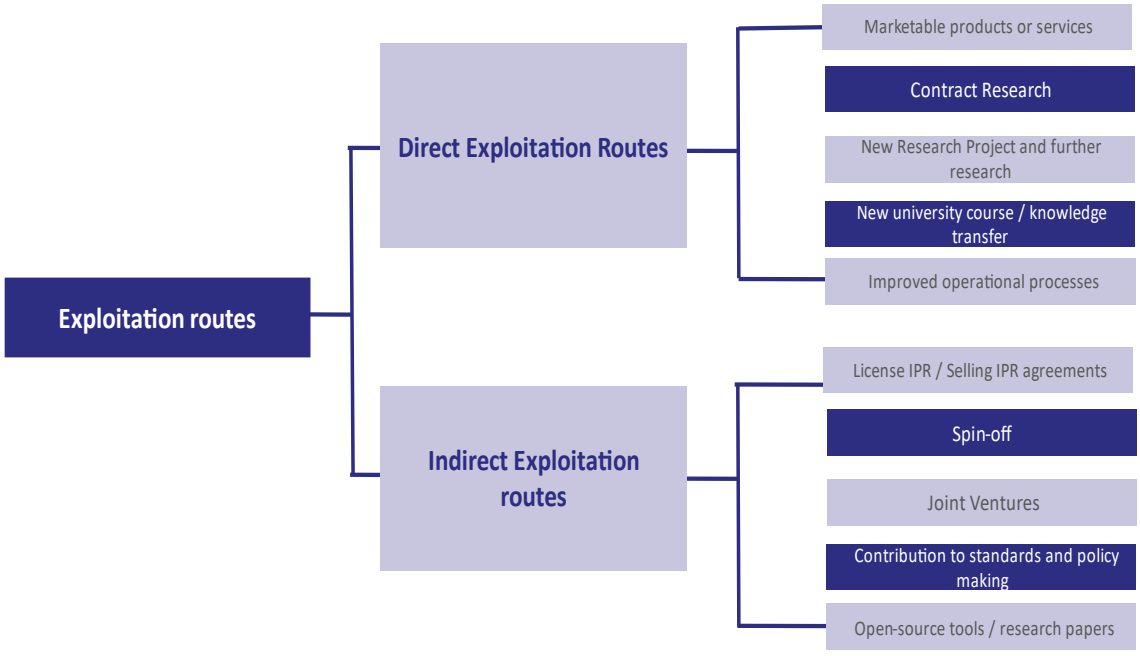


Figure 26: General Exploitation routes

4.1 Individual Exploitation

Throughout the project's lifecycle, an evaluation of its exploitable outcomes will be conducted. To facilitate this assessment, CORE prepared a standardized template for the consortium. This template is designed to systematically collect the necessary information related to technological, commercial, and intellectual property aspects (Figure 27).

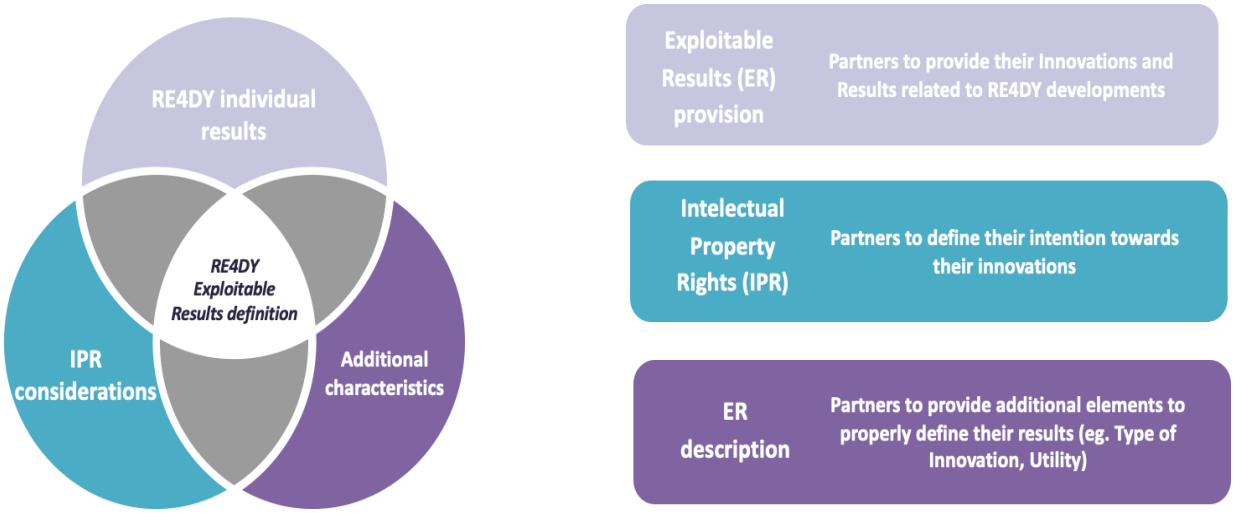


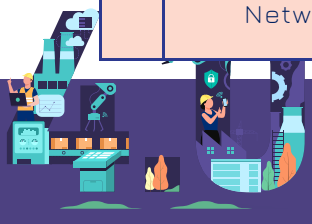
Figure 27: Individual exploitation concept

Each contributor to exploitation will utilize the shared templates to document their individual exploitable results. The circulation of this template among partners aims to ensure a structured approach to identifying and managing individual exploitable results throughout the project staying in synch with the technical developments. The table 7 presents the outcomes during the initial iteration of identifying exploitable results. This list may be subject to further changes if additional results emerge, or modifications are necessary to remain in synch with the ongoing developments.

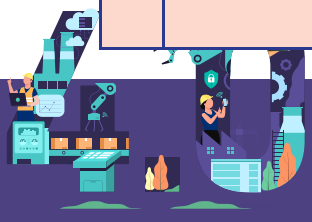
The project will undergo continuous evaluations of exploitable outcomes. The initial iteration of exploitable results, as presented in the table below, covers a diverse range of outcomes owned by various partners. These results will make significant contributions both commercially, driving industry advancements, and non-commercially, expanding the research and policymaking in the context of manufacturing data spaces. In a nutshell, the inclusion of threat testing and operational security services enhances industrial cybersecurity, contributing to a secure and resilient manufacturing environment. The introduction of AI models and federated learning along with the decentralized data analytics contributes to the commercial success by enhancing defect detection, tool maintenance, and predictive maintenance capabilities. The non-commercial outcomes facilitate the showcasing and demonstration of advanced data spaces, contributing to research and development effort. Results like Data Spaces Test Bed and Test Bed and Data Sets are shared as open source, focusing collaborative innovation, and providing valuable resources for experimentation. The Active Resilience Framework and RE4DY Framework will be accessible under open-source licenses, promoting transparency, accessibility, and wider adoption within the research community.

Table 7: RE4DY Individual Exploitable results

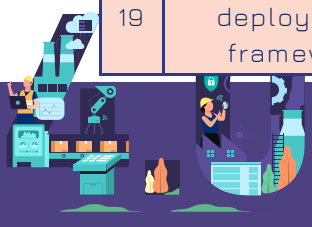
ER #	Individual Exploitable Result	ER Owner	ER Description	ER Utility
1	DC threat testing & operational security	S21SEC	Threat testing & operational security awareness services	Improve the cybersecurity incident detection and response enhancing network protection against threats.
2	Decentralized data management & analytics component	CNR	A set of algorithms and prototypes for decentralized data analytics	Provide to EU industrials sectors with a set of algorithms to extract knowledge from data in decentralized industrial networks without moving them from generation point they are generated
3	Knowledge acquired in Manufacturing dataspaces domain	IDSA	Asset for knowledge transfer/sharing	Incorporate into Dataspace radar, showcase in events and conferences to introduce new data sharing scenarios and promote the dissemination of the Data Spaces concept
s4	Data as a Product Container	UPV	Abstraction layer to access the data following the Data as a Product approach	Enable access to the data (Data as a Product principles) considering the consumer's requirements in terms of format and data quality, with the proper considerations about security, privacy, and performance.
5	Data Connection Profile	UPV	A standardized definition of the access and use of the data, with the proper privacy, data governance and quality considerations	Facilitate the integration among complex systems in a standard, simple, durable, and context-sensitive way
6	AI model (defect detection)	POLIMI	Training datasets for AI-based Computer Vision application,	Provide to EU industrials sectors methods and tools to deal with automated Quality Control in a context of increased flexibility.
7	Didactic Factories and Experimentation Facilities Network	POLIMI	Network of Didactic and Learning Factories (as well as Digital Innovation Hubs) to leverage on, in the	Provide to EU community a geographically granular network of competences able to accompany SMEs in designing and developing their road towards their digital transformation, as well



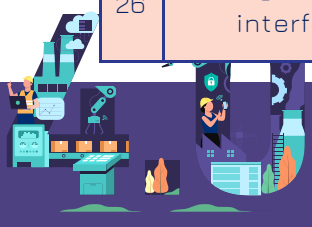
			building of an ecosystem of skills and services providers	as an ecosystem of actors supplying these realities with services and competences.
8	Federated Learning for Milling machines (FEDMA)	CORE	Software solution for Federated Learning, ensuring data privacy and enabling secure, independent model training on the Edge	Introduces a paradigm shift in how machine learning models are trained, ensuring data privacy, and aligning with the EU's data protection laws. Enhance the accuracy of defect detection and tool maintenance but also offers continual refinement and improved predictive capabilities.
9	Data Spaces Test Bed	SANDETEL	A demo environment for showing the functionality of the data spaces	Provide a novel test bed to facilitate the showcasing and demonstration of advanced data spaces.
10	Predictive Maintenance Application for Milling Machines (My rConnect platform)	GFMS	Software module for critical component health diagnosis and residual lifetime prediction using artificial intelligence	Provide EU industries using milling machines a service for controlling the health of the equipment and program repair or component replacement
11	Tool Management Application (My rConnect platform)	GFMS	Software module for monitoring tool wear and residual useful lifetime during manufacturing of parts	Provide to EU industries using milling machines an application for maximizing the use of tools and reduce part manufacturing costs, while guaranteeing part quality and facilitating the recycling of such tools and the reduction of the CO2 footprint of the manufacturing process
12	Data exchange model and framework	GFMS	Software module for critical component health diagnosis and residual lifetime prediction using artificial intelligence	Provide EU industries using milling machines a service for controlling the health of the equipment and program repair or component replacement in due time without risk of unplanned interruption of production processes
13	FPdM (Federated Predictive Maintenance)	ATLANTIS	Software solution/product with predictive capabilities for quality defect detection and tool maintenance	The FPdM will provide EU industrial sectors with a holistic view of their production lines by interpretation of detected machine errors and quality defects. Connection with Federated Learning



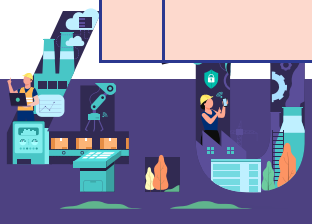
				Frameworks is expected to optimize the models' training and consequently the results.
14	eIDAS Compliant Identity Management Solution Data	INTRA	Middleware Solutions enabling the management of user's base on eIDAS proof of identify	Enable the development of identity and Access Management) solutions that are compliant to the eIDAS proof of identify
15	Decentralized Data Provenance and Traceability	INTRA	Blockchain solution offering Decentralized Provenance and Traceability for Industrial Data	Boost the trustworthiness of industrial data, which are inherent unreliable due to various factors
16	Active Resilience framework	CHALMERS	The resilience framework forms the basis for creating a resilience dashboard comprising a compass and a radar	A resilience compass to provides EU manufacturing companies and their supply chains with a holistic view of the different dynamic capabilities they need to develop in the three resilience stages of anticipation, coping and adaptation
17	RE4DY Framework	CHALMERS	Flexible Time-Series based AI-model which can adapt to heterogenous industry data	Enable companies to combine heterogenous data from multiple sources and use them in one model. This will enable higher model performance for quantitative risk management or forecasting ,enhancing operational management performance.
18	Industrial Data marketplace	ATOS	Secure, interoperable, and highly efficient environment for organizations to seamlessly exchange, store, and manage data across a wide range of industries.	A service to support: • Data Governance and Compliance • Improved Accessibility: • Efficiency • Interoperability • Quality and Consistency • Cost Reduction: • Automation and Scalability • Security • Monetization: • Contract management:
19	Digital Twin deployment framework	SIE	Continuous delivery services for executable	Open Test and experimentation (TEF) demonstrator of the resilient



			cognitive digital twin engineering, commissioning, and operation	a sustainable distributed computing and data space for connected factories and supply network service experimentation
20	XAI and Active Learning Platform	CERTH	A defect detection & localization platform in hard metal Industry accommodated by AI explainability and human-AI in the loop mechanisms	Provide to EU industrial sectors (sectors involving machine tools and hard metal) a complete solution for the enhancement and automation of Quality Control in the cases it is related to visual inspection
21	Sovereign Data Transformation Services	CERTH	Service that provides data transformation and integration services between different components	Provide to various EU sectors a solution as a service that will enable the 'on-the-fly' data integration and transformation
22	Testbed	SSF	Improvement of existing test and demonstration facility	Expansion and enrichment of SSF ecosystem of demonstrators and knowledge to support industry adoption of cutting-edge technologies
23	Robotic energy optimization application	FILL	Software application for monitoring and optimizing the energy consumption of robots	Provide to EU industries using robots in manufacturing an application to reduce energy consumption and power peaks in the manufacturing process
24	Design for Manufacturing (DfM)	FILL	Software application for the resilience of the product and the production process to rate its flexibility and reconfiguration potential	Provide EU industries using automated manufacturing with a service to assess the product flexibility of their production line to increase long-term sustainability and enable future scalability
25	Logistics Knowledge Graph	ICF	Knowledge reference for automotive assembly logistics	Provide Automotive sector with a knowledge reference framework to increase the accuracy of analysis of big data instances in assembly lines and improve the quality of decision making
26	Dynamic interface	ICF	Interface for improved decision-making across	Improved decision-making systems integrating production data instances



			manufacturing value networks	dynamically with ontology reference data and interaction with third party data from external IPR systems.
27	Asset/IPR Management	ICF	Integration of IPR and innovation landscape databases	Provide Manufacturing Value Networks with integrated overview of IPR landscape of available assets by access to IPR reference (WIPO, EPO, worldwide patenting databases)(normalized) via NLP query and API allowing for more effective exploitation of IP gaps and asset resilience management.
28	Asset Administration Shell for 5G User equipment	UMH	A standardized digital representation or Digital Twin of a 5G User Equipment (UE). It provides relevant information and features of a 5G UE.	Provide to relevant EU stakeholders with the digital twin or digital model of the User Equipment of the 5G network that supports the industrial plant or manufacturing processes. The digital twin of the 5G UE can be integrated with the digital twin of the industrial plant or manufacturing processes to construct the digital twin of the complete production system
29	TEF Services	INNO	Testing & Experimentation Facilities to support manufacturing organizations and developers bringing products and machinery to the market more efficiently	INNO as a TEF has developed exploitable Technical and Business Services such as: • Data spaces / Data sharing services • Real Time Industrial Data Platform, Assets Administration Shell, and Monitoring platform • Connection to funding sources, consortia creation and proposal development) • Ecosystem building services • Skills and maturity assessment services • Industry 4.0 & AI Ideas generation, technology readiness assessment, strategic and specific R&D, Proof of Concept development
30	Testbed platform	ENG	AI/ML-based defect detection tools support quality inspections, guiding operators	Support the industrial stakeholders involved: • Favor the training, the up-skilling, and the re-skilling of both senior and junior employees.



			to potential areas of concern	• Empower the training of junior operators, decoupling training from the availability of senior inspectors • Increase in operational efficiency enhancing precision in key process stages • Optimize the component quality inspection process, providing a range of benefits and positive outcomes
31	Digital 4.0 continuum Reference Architecture	ENG	A Reference Architecture which aims to facilitate the implementation of digital continuity across Digital Threads, Data Spaces, Digital Twin workflows and AI/ML/Data pipelines	To provide to EU industrials sectors (Automotive, machine & cutting tools, aeronautics and eBattery industries) with a digital Continuum Reference Arhitecture that leads solutions capable to: • reinforce decentralization on infrastructures, services, and data planes. • ease exploitation of the digital thread, regardless of where data and applications are • exploit the concept of DaaP, as a marketable digitization of the value chain (data space); • create convergence for Manufacturing and IT operations, natively by integrating toolkits covering the whole lifecycle of an Industrial Data Platform

Overall, the project's initiatives collectively address the evolving needs of European industries, paving the way for a digitally transformed industrial landscape. The project fortifies incident detection and response, ensuring network protection against threats. Algorithms for decentralized data analytics empower industries with knowledge extraction, fostering insightful decision-making. Secure and sovereign data sharing is realized through the establishment of an Industrial Data Space, creating a trustworthy collaborative environment. Optimizing data access based on Data as a Product principles, the project tailor's information utilization to meet consumer requirements while prioritizing security, privacy, and performance. Standardized system integration simplifies complex processes, promoting interoperability and efficiency. Methods and tools for automated quality control enhance product quality and operational efficiency. The establishment of a competence network supports SMEs in digital transformation, creating an ecosystem of

skills and services. A paradigm shift in machine learning aligns models with data privacy and EU regulations, significantly improving defect detection and predictive maintenance accuracy. Innovative test beds showcase advanced data spaces, fostering the adoption of cutting-edge technologies. Services for predictive maintenance in milling machines optimize equipment health, minimizing downtime. Maximizing tool use and reducing manufacturing costs, contribute to sustainability and cost reduction. The Federated Predictive Maintenance (FPdM) offers a holistic view of production lines, interpreting machine errors and defects, optimizing model training for improved results. The compliant identity management enhances security and compliance, while boosting trustworthiness address's reliability concerns in industrial data. A resilience compass provides a holistic view of dynamic capabilities for companies and supply chains, enhancing overall resilience. Heterogeneous data integration improves model performance, while the industrial data marketplace supports diverse aspects, from governance to monetization, fostering comprehensive data utilization. A digital twin deployment framework enables resilient distributed computing, supporting connected factories. Quality control in hard metal industries is enhanced, and on-the-fly data integration services offer flexibility and efficiency across various sectors. The adoption of cutting-edge technologies, and applications for robotic energy optimization and product flexibility assessment contribute to sustainability and efficiency. In essence, the RE4DY project collectively will advance European industries into a technologically advanced, resilient, and sustainable future.

4.2 IPR management

The Intellectual Property Rights (IPR) section describes the critical aspect of the project that underscores the importance of safeguarding and managing the knowledge generated throughout the project. This section outlines the mechanisms considered for IPR but also emphasizes on developing a robust IPR strategy. By doing so, we aim to protect our results and prepare the way for future monetization efforts, innovation, and the responsible dissemination of knowledge. Expanding on the exploitable results, aiming to streamline the exploitation model, the partners have outlined a preliminary strategy for safeguarding their contributions to exploitation. The proactive consideration and strategic management of IPR elements will ensure the effective commercialization of the project's outcomes. For the definition of IPR, various mechanisms were considered:

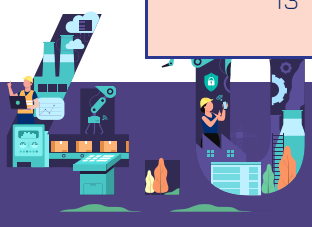
- Copyright ©: Copyright is a legal safeguard granted to original works, encompassing software creations and affords owners exclusive rights, to manage the reproduction, distribution, and public display of their creations. Copyright protection is inherent upon creation and endures throughout the author's lifetime plus a specified number of years.

- Trademark ™ : Trademarks serve as shields for brands, distinguishing the goods and services of one entity from others. Offering indefinite protection as long as the trademark is actively used, trademarks are important for brand recognition. They differentiate products or services associated with a specific brand.
- Patent ®: Patents are built upon inventions or innovative technical products providing novel solutions to technical challenges. These grants exclusive rights to the owner, enabling them to restrict others from making, using, or selling the patented work without consent. Patents endure for 20 years from the filing date and protect the functional aspects of the invention. Patents stimulate research and development by granting a period of exclusivity for commercializing the invention.
- Open-source license: An open-source license is a legal agreement that grants permission to use, modify, and distribute a software program's source code (MIT license, Apache License, GNU General Public License -GPL-). Open source refers to exclusively to software. It means that the source code for that software is openly available, thus allowing for modification, and that the software may be redistributed freely.
- Open-source access: Open access (or OA) refers to unrestricted public access, usually in the context of research.
- Database rights: Database rights refer to the legal protection granted to the creators or owners of a database. Database rights provide a level of protection against unauthorized extraction of substantial parts of the database.
- Licensing agreement: A licensing agreement is a legal contract between two parties, the licensor, and the licensee, that outlines the terms and conditions under which the licensor grants the licensee the right to use, produce, sell, or distribute a specified intellectual property. Key components of a licensing agreement typically include Scope of use , duration, royalties-payments fees, confidentiality, and termination clause.
- Joint IP Ownership: Joint intellectual property (IP) ownership occurs when multiple partners collectively share control over the copyright, trademark, or patent associated with a particular creation or innovation. This circumstance typically arises when two or more entities collaborate on the development or production of intellectual property. Joint ownership is a legal framework that defines the collaborative control, usage, and commercialization of the shared intellectual property among the involved entities.

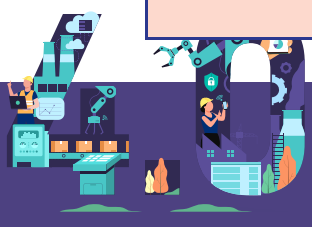
Below a table showcasing the IPR protections method for each exploitable result as described by the partners:

Table 8: RE4DY IPR mechanisms (individual results)

ER #	Individual Exploitable Result	Exploitable Result Owner	IPR mechanism
1	DC threat testing & operational security	S21SEC	Open-source license
2	Decentralized data management & analytics component	CNR	Open-source license
3	Knowledge acquired in manufacturing data spaces domain	IDSA	Open-access
4	Data as a Product Container	UPV	Copyright
5	Data Connection Profile	UPV	Copyright
6	AI model (defect detection)	POLIMI	Open-source license
7	Didactic Factories and Experimentation Facilities Network	POLIMI	Open-source license
8	Federated Learning for Milling machines (FEDMA)	CORE	Copyright, Licensing
9	Data Spaces Test Bed	SANDETEL	Open-source license
10	Predictive Maintenance Application for Milling Machines (My rConnect platform)	GFMS	Patent
11	Tool Management Application (My rConnect platform)	GFMS	Copyright, Patent
12	Data exchange model and framework	GFMS	Patent
13	FPdM (Federated Predictive Maintenance)	ATLANTIS	Copyright, Licensing



14	eIDAS Compliant Identity Management Solution Data	INTRA	Licensing
15	Decentralized Data Provenance and Traceability	INTRA	Licensing
16	Active Resilience framework	CHALMERS	Open-source access
17	RE4DY Framework	CHALMERS	Open-source access
18	DIDI Data marketplace(Industrial Data Marketplace)	ATOS	Copyright, Patent
19	Digital Twin deployment framework	SIE	Open-source, Know-how
20	XAI and Active Learning Platform	CERTH	Copyright, License agreement
21	Sovereign Data Transformation Services	CERTH	Copyright, License agreement
22	Testbed	SSF	Commercial license
23	Robotic energy optimization application	FILL	Commercial License, Copyright
24	Design for Manufacturing (DfM)	FILL	Commercial License, Copyright
25	Logistics Knowledge Graph	ICF	Open-source, Copyright
26	Dynamic interface	ICF	Commercial License, Copyright
27	Asset/IPR Management	ICF	Commercial License, Copyright
28	Asset Administration Shell for 5G User equipment	UMH	Copyright
29	TEF Services	INNO	On-demand services
30	Testbed platform	ENG	Commercial License, Copyright



31	Digital 4.0 continuum Reference Architecture	ENG	Open-source access

The chosen IPR mechanisms for the RE4DY project are diverse, reflecting the nature of the individual exploitable results. In summary, the mix of IPR mechanisms demonstrates a thoughtful and tailored approach to protecting, sharing, and leveraging the intellectual property generated by the RE4DY project. The combination of open collaboration through open-source licenses, protection for critical components, and strategic use of patents and licensing reflects a holistic strategy for maximizing the impact of the project outcomes. This approach not only empowers innovation impact but also facilitates the broader adoption and sustainability of the developed solutions. The work accomplished thus far will be further elaborated and discussed with the partners to formulate a final and concrete IPR management plan. This process will run parallel to the technical developments of the results. The joint ownership of the results will also be collaboratively developed and defined by the consortium as the project progresses in the context of joint exploitation scenarios.

4.3 Joint Exploitation

Joint exploitation involves the collaborative utilization of project innovations to generate benefits for the industry. It leverages the collective efforts made throughout the project lifecycle, enhancing the market offering and impact of individual exploitable results.

For the purposes of RE4DY the joint exploitation strategy will be designed during Phase 2 as outlined in the work plan (Figure 24) and will be further elaborated and presented in the next version of the deliverable. The partners will engage in discussions regarding joint exploitation scenarios, aiming to reach a consensus on the final exploitation plan. This decision will be informed by factors such as the nature of project outcomes, partners' intentions for their results, technical considerations of the developments, and alignment with current industry and market needs.

The general framework for RE4DY's Joint Exploitation Strategy is marked upon the Manufacturing X Ecosystem context. 10 nations have come together to establish the International Manufacturing-X (IM-X) Council, with its official announcement at the 2023 Annual CESMII Member Meeting hosted at SOUTHTEC's Smart Manufacturing Experience Oct 24-26 in Greenville, SC (CESMII 2023). IM-X puts data front and center encapsulated by the tagline "Make data work". Recognizing the pivotal role of software in digitizing manufacturing and the necessity of data as critical input for any software application, IM-

X envisions to implement a federated, decentralized, and collaborative data ecosystem for smart manufacturing globally (U.S. DoE 2023). The United States of America are joining Germany (Plattform Industrie 4.0), Austria (Plattform Industrie 4.0 Österreich), Australia, Canada (Offensive de Transformation Numérique), France (Alliance Industrie du Futur), Italy (Confindustria), Japan (RRI), Netherlands (Smart Industry), and South Korea (KOSMO) in launching this initiative (Industrie 4.0 2023).

Considering increasing digitalization and the resulting requirements, manufacturing throughout the world is facing unprecedented challenges and opportunities where the real and virtual world will continue to coalesce. The entire value chain will be integrated and supported by digitalization, from product, production and process design to onsite customer service and circularity – across locations as well as company and national boundaries. IM-X will implement a federated, decentralized, and collaborative data ecosystem for smart manufacturing. Open, global, and cross-sectoral based on Resilience, Sustainability, and competitiveness.

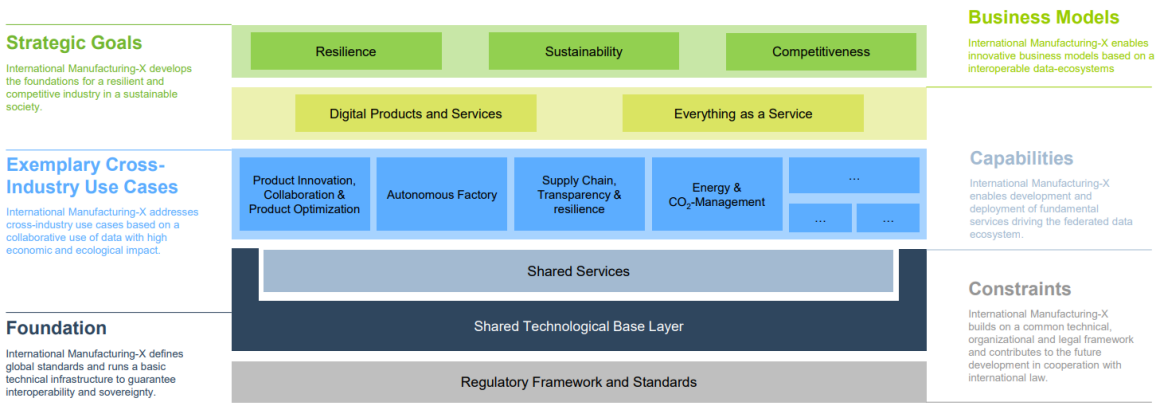
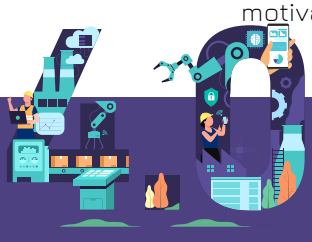


Figure 28: International Manufacturing X Infographic

Following the above-mentioned international context, the RE4DY Exploitation activities aim at transforming the project's outcomes into exploitable assets creating an ecosystem among European Data Value Networks, which will operate as a powerful and extended distribution channel for innovation services.

The project's exploitation strategy is based on four complementary paths:

1. A path for joint exploitation aimed at ensuring the sustainability and wider uptake of the project's repurposing manufacturing services.
2. A path dedicated to the establishment and provision of joint innovation management services for the knowledge transfer to other industrial sectors both at regional and national level to create and enhance business innovation and motivate with clear evidence of sectorial transformation.



3. A path entailing the development of detailed exploitation plans by each individual partner, in-line with each partner's business and research strategy in the digital manufacturing market. In most cases, these plans concern the improvement of existing products and services of the partners.
4. Exploitation of the use cases and pilots of the project, notably the pilot systems that will be used to validate the project's developments. The pilots will provide early showcases of the project's functionalities, and they will be gradually advanced in terms maturity and market readiness towards a viable route to market.

In this context, RE4DY's Joint Exploitation Strategy profits from its PR Office structure, the Digital Factory Alliance (DFA) providing two main lines of exploitation:

- Innovation-driven exploitation activities: providing for an open community to develop open innovation spaces, joint innovation management services provision market, joint exploitation ground and a governance model.
- Market-driven exploitation activities: providing for an open collaborative space for individual innovation solution marketization.

A further exploitation route to empower the RE4DY results and leverage synergies among already existing ecosystems and initiatives has been identified in the Digital Factory Alliance (https://digitalfactoryalliance.eu/),named in short DFA. To harmonize the information to be presented in the RE4DY digital channels and in the DFA website, an ENG asset (namely the DYMER) already in use within the DFA digital ecosystem has been identified to play the role of Catalogues Management System (CMS) constituting the central component to realize a Content Management System as a Service, the cornerstone of the interoperability among RE4DY and DFA tools, as well as with other external portals. The overall vision as depicted in Figure 29 is to follow a "Single Point of Knowledge" (SPoK) approach, the stakeholders should be able to find all the information related with the RE4DY results in a unique journey, retrieving through backend calls multiple sources.

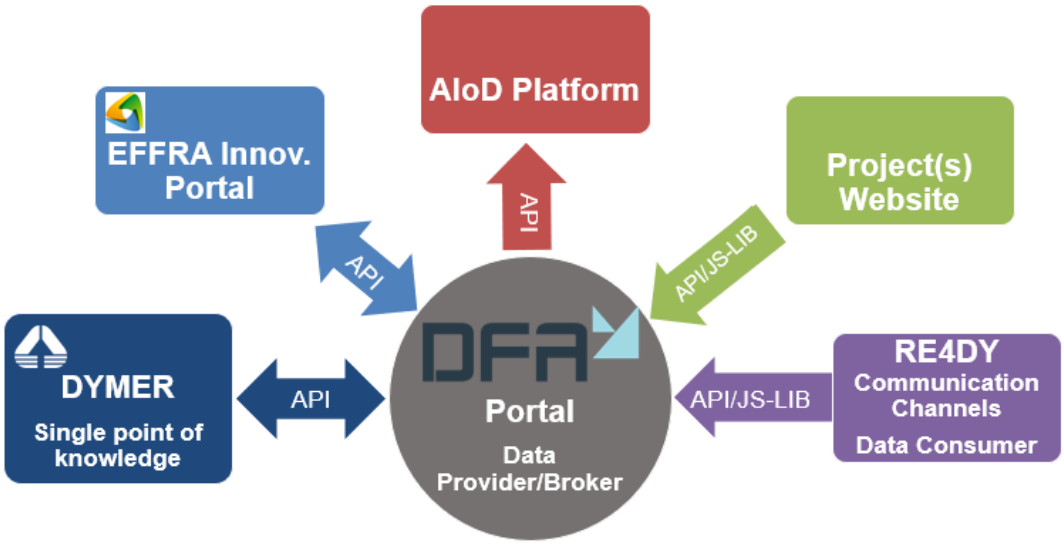


Figure 29: Digital Factory Alliance with RE4DY component

The DFA is leveraged as a vehicle to empower the RE4DY digital presence and to ease the connection (as a broker) to other relevant portals/initiatives such as EFFRA, AIoD and others, but keeping the DFA as SPoK for the ecosystem managed. Thus, the DFA Portal will be the window to promote the relevant results/use cases/events available on the respective projects' websites/portals. The need for a centralized approach to knowledge management has become increasingly evident in today's data-driven world. An effective management of the information on reference business cases, projects exploitable results, publications, and all relevant content for the RE4DY initiative is critical to attract, interest and keep the stakeholders on the DFA radar. The centralized approach on data/content management ensures that data is consistent, accurate, and up to date (single source of truth, SSOT), allowing the implementation of robust security measures (on a single environment), and overall is easily maintainable with respect to decentralized architectures.

During the project period, the consortium is governed by the Consortium Agreement, but once RE4DY enters its full exploitation phase after the end of the project, partners will have to agree on a shared governance model. Such a model will essentially be the means to control the RE4DY Exploitation in the post-project phase ensuring that objectives are pursued and met. The chosen governance model and methods are strongly interrelated to the business models described above. The following factors will have to be considered:

- Objectives clearly in line with the exploitation objectives and compatible with the ownership models and IPR strategies.
- Model chosen for the governing entity/initiative to pursue the above objectives.

- Roles partners are willing to undertake. These roles shall be formalized through specific agreements for partners to sign, committing to the defined role(s).
- Rules for participation. In particular, the consortium shall have to decide if it wants to pursue a model where only current project partners can join, or where external participation is foreseen.
- Additionally, rules and schemes, including fees and revenue sharing, will be clearly set out.

For the post-project governance phase, in RE4DY three main approaches are proposed and will be carefully considered, given the project nature and partners' characteristics, all of which have reportedly been successfully applied in other European IT research projects. The three approaches are described hereafter, also highlighting the main pros and cons:

1. New Legal Entity Approach:
    a. Description: With this model, a new legal entity is created to manage the foreground generated and to pursue both commercial and non-commercial objectives of the RE4DY exploitation. This model foresees strong centralized management (company-like) and typical roles covered by partners who would usually provide staff and resources. The creation of a legal entity tends to face a certain degree of legal and 'bureaucratic' difficulties, thus certainly timing can be long. It enables a strong implementation of the exploitation strategies and, once set up, would prove rather stable. Partners could join with different roles (as partners, stakeholders, etc.) and various levels of commitment. It should be mentioned that joining a profit-making entity might not always be a viable solution for some partners (e.g. non-for-profit and research organizations), however, various solutions exist for their involvement. There exists a risk that creating a new legal entity might result in a too convoluted and resource- and time-consuming activity. Additionally, the costs (i.e. overhead) for implementing and maintaining such a monolithic structure should be factored in and their long-term sustainability seriously taken into consideration.
    b. Pros: Central, Efficient Management, Stricter implementation of exploitation strategies and stable.
    c. Cons: Bureaucracy overhead, high monetary initial investment needed, resource-consuming to run, not very flexible and may not be viable for some partners.
2. Joint Venture Approach:
    a. Description: Through a joint venture new business opportunity could be pursued by RE4DY partners who would also contribute with resources

(financial, assets, skills, staff etc.) and share benefits and risks in the endeavor. In this case, a partnership would be created where shares could vary among partners. While a legal entity doesn't necessarily need to exist, a joint venture could use two partnership models (a new organization possibly managed by one of the partners or without any organization, like the current collaborative project model). In both cases, a centralized joint venture agreement would be required to establish revenue, risks and liability sharing. This should make clear how decision making is carried out, setting up a board where the strategy and actions are decided. Venture partners should cover roles like those of a legal entity. The most complex part of setting up the joint venture is to agree for all partners on the costs and revenue sharing (who pays what and who cashes what). While more flexible than creating a legal entity, the RE4DY partners expressed concern that this model also poses the risk of being too constrained. For some partners, it could still be hard to formally engage (and commit) to providing (even non-monetary) resources to the venture and sign such a type of agreement. Although lower compared to a legal entity, the costs for management (e.g. board meetings etc.) should be factored into this model.

b. Pros: Shared benefits and risks, Flexibility, allows for both central and/or shared management, and allows to be widened to non-project entities.
c. Cons: Important changes need everyone's approval (slow), may be harder to define profit sharing mechanisms, lengthy process to set up the Venture and agree on revenue and cost models, some partners (e.g. academia) may not be able to join due to legal constraints and bureaucracy.

3. Multilateral Collaboration Agreements Approach:
   a. Description: This model foresees flexible business agreements, with a series of partners collaborating in the delivery of products and services based on RE4DY, without a central structure or entity. Therefore, a global agreement is not strictly necessary. In fact, each partner becomes a 'link' in a supply chain and essentially establishes agreements with the other interested partners: clearly agreements between the involved parties are required but offer a high degree of flexibility. Typically, this partners' chain will be covered by all or most current RE4DY partners, who will also be free to establish other business agreements with third parties. This type of governance will usually include at least the following actors/functions: sales, providers, and consultancies. Adopting this flexible model will ensure that if certain roles cannot be covered by partners, third parties can be added. Partner responsibility will mostly be 'localized' in that partners will be responsible for delivery of their own product/service. Ownership and

IPR are easily managed in this model, as each partner owns and manages its share and possible further agreements can be made on a case-by-case basis.

b. Pros: Little bureaucracy, relatively easy to set-up, maintains partners' flexibility, all kinds of partners can participate, fits well with the Virtual Enterprise model, and well suited to exploit modular assets in diverse environments.
c. Cons: Risk of individual objectives clashing, weak global objectives, might favor some partner over others, and changes in links might disrupt the chain.

As for IPR Management the Consortium will evaluate the best strategy to be followed to maintain RE4DY results running for a period after the project ends, and accessible by both RE4DY partners and possibly interested third parties. The final model will be presented in the final version of the Exploitation Plan.

5 RE4DY Value network

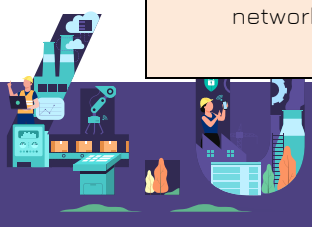
5.1 Stakeholders Engagement Objectives

Stakeholders play a crucial role in RE4DY, involving them enhances collaboration and increases the project's chances of success. Having clear stakeholder engagement strategies and objectives will ensure that the outcomes of RE4DY align with the needs of the manufacturing sector and the broader EU goals.

Before setting stakeholder engagement objectives, one must identify target groups where these stakeholders are located. This has been done in deliverable 6.1, the "Skills development, knowledge transfer and communication plans". According to this document, 8 different stakeholder groups have been identified and specific objectives have been set for each one of them. This can be found in the table below:

Table 9: RE4DY target stakeholders' group

Target groups	Objective
Research and scientific community	Emphasize the developed new concepts, circular chains and sustainability by design and AI in manufacturing for future research in the Academia and access to Open data repositories.
Manufacturing EU sectors linked to RE4DY pilots	Show RE4DY objectives and key results, technologies developed and validated, with respective benefits from Connected Factories and Digital 4.0 Continuum.
Related projects	Meet common ground, interests, and actions in the fields of IoT, AI, Intelligent Manufacturing, Industrial Informatics.
EU organizations, financial actors, and policy makers	Share valuable results from the project and knowledge that can be applied in many sectors.
General public and media	Raise awareness of the project's benefits for society on sustainably designed products.
Associations, alliances and DIHs	Diffuse project generated knowledge and how the results can be exploited. Enable them to build their own RE4DY value networks.
Manufacturing community, DFA networks and DIHs	Share scientific discoveries, knowledge on toolkits, Data as a Service and Federated Learning for resilient manufacturing and Supply Chain.



Sustainable manufacturing platforms, DIHs and research organizations	Disseminate knowledge and the benefits of implementing the Action plan and adaptation of Industry 5.0 principles.

In order to achieve the aforementioned objectives, IDSA (responsible for T6.4 "Value network & data space business development") will provide concrete plans for the stakeholder engagement strategy, including clear steps for stakeholder identification, engagement methods and stakeholder monitoring and evaluation.

5.2 Stakeholders Engagement Strategy

5.2.1 Adaptation and improvement

Identifying the desired stakeholder groups to be engaged, even the actual organizations to be approached and then setting individual objectives and strategies to achieve them will not guarantee success. The environment in which RE4DY evolves, especially the European manufacturing sector, can be subject to many changes.

For starters, the project has a duration of 36 months, a lot can happen in three years. Organizations, even within the project, can cease to exist, reduce their scope, change their strategy or primary focus and so on. Not only that, but the problem can be as simple as the results of the initial approach to a stakeholder being different to the expectations from the project. This can happen due to several factors, including a not well-planned engagement strategy, not being prepared enough, approaching the wrong contact person within one organization, or having done it at the least optimal time and/or place.

In order to overcome this, the stakeholder engagement plan has to be adaptable or modified in response to changing stakeholder dynamics and project requirements. The following are strategies that can serve this purpose:

- Regular Assessment and Review: Conduct regular reviews of the stakeholder engagement plan to identify any changes in stakeholder dynamics, project requirements, or external factors. This ongoing assessment helps in staying proactive and responsive to evolving circumstances.
- Flexible Communication Channels: Maintain flexibility in communication channels. If new stakeholders emerge or if existing ones prefer different communication methods, RE4DY should be prepared to adapt.
- Stakeholder Analysis Updates: Periodically revisiting the stakeholder analysis to ensure it remains accurate and up to date. Changes in stakeholder priorities, interests, or influence can impact the overall engagement strategy.

- Revised Engagement Strategies: Modify engagement strategies based on the changing dynamics. If certain stakeholders become more influential or if their priorities shift, RE4DY must tailor its engagement efforts to address their concerns and expectations. This may involve adjusting the frequency of communication or altering the project content to be more relevant.
- Additional Stakeholder Identification: As the EU manufacturing ecosystem is continuously changing, RE4DY will identify and incorporate new stakeholders as the project progresses. Stakeholder landscapes can evolve, and new entities or individuals may become relevant to the project.
- Surveys and Feedback Mechanisms: The project will implement surveys and feedback mechanisms to gather input from stakeholders on the effectiveness of the engagement plan. This feedback can highlight areas that need adjustment and provide insights into evolving stakeholder expectations.
- Scenario Planning: It is important to anticipate potential changes in stakeholder dynamics or project requirements through scenario planning. If needed, the project will develop contingency plans that outline how the engagement plan will be adjusted in response to different scenarios, allowing for a more rapid and informed response.
- Collaborative Decision-Making: It might be beneficial to involve stakeholders in the decision-making process related to engagement strategies and to seek their input on how the plan can be adapted to better meet their needs and expectations. This enhances stakeholder buy-in and ensures that adjustments are well-received.
- Transparency and Communication: Changes in project requirements or stakeholder dynamics will be openly communicated to the stakeholders.

By implementing the adaptation and improvement strategies, stakeholder engagement within RE4DY can run smoothly and contribute to the success of the project.

5.2.2 Roles and Resources allocation

It is of key importance to be clear when it comes to establishing roles and responsibilities for the stakeholder management within the project. The task where the stakeholder management of the project is included is T6.4 “Value network & data space business development”, led by the International Data Spaces Association (IDSA). This task is part of the “Dissemination, Exploitation, Skills & Global Impact” work package, WP6. The partners contributing to this task are Innovalia, Politecnico di Milano and CORE. The role of IDSA is that of task leader, which means that they are responsible for the elaboration of concrete plans for engagement of stakeholder community into resilient value network development to take part in piloting and innovation activities related to RE4DY. For this, they will provide

a plan to raise awareness, interest and dynamize the participation of external stakeholders, mainly SME´s, to the RE4DY initiative.

The role of the rest of the consortium partners is that of contributors, which means they are responsible for contributing to the stakeholder engagement plans and strategy, by actively leveraging the dissemination and communication resources, as well as the project tangible assets, to approach and engage the stakeholders that conform the target groups identified in section 5.1.

This should be done in close coordination with the task leaders and every interaction, outcome and follow-up actions must be documented. The tool that will be used to collect this information, including the name of the partner assigned to each stakeholder, resources, status and next steps is the stakeholder tracker excel. Every partner will have access to it and must keep it up to date.

The consortium will have access to different communication and dissemination resources, that will be made available by the WP6 partners and the Digital Factory Alliance, which acts as the PR office for the project.

Said communication and dissemination resources are the following:

- Website: This will be the main source of information for the project´s stakeholder community and can be accessed under https://re4dy.eu/.
- Social media channels: Twitter and LinkedIn will be used to share the latest news from the project and to engage its community at the same time.
- Videos: Videos will help the stakeholder community understand the value and the assets delivered by the project.
- Publications: It is planned to release at least 10 publications and scientific papers via the project´s and partner´s websites. This will help engage the scientific community in particular.
- Dissemination materials: A logo branding set, presentation templates project factsheet, posters, roll-ups, and infographic designs will be made available to the consortium for dissemination purposes.
- DFA Newsletter: This will inform the target audience of the latest news, tips of updates related to the project.
- Events, Conferences and Fairs: The partners of WP6 will inform the consortium of upcoming events where the project can be presented, its results can be showcased and disseminated and where the attendants might be the same as the target audience. This can be found in the events tracker.

5.3Stakeholders Analysis

5.3.1 Stakeholders identification

As part of the Stakeholder Analysis, the first step is to identify the stakeholders of interest to the project. The identification of stakeholders will be recorded in the RE4DY Stakeholder Tracker excel. In this document, the stakeholders that are relevant to the project will be sorted according to the following points:

- ID
- Stakeholder name
- Main contact
- Role within the organization
- Country
- Domain
- Interest/Power level (according to the Stakeholder Matrix)
- Engagement strategy (to be defined in step 2)
- Unique facts
- Stakeholder expectations (what do they expect from the project?)
- Expectation management
- How and when did we established contact with them?
- Internal responsible
- Follow-up actions

As an international association that has been active since 2016, IDSA counts on a broad member base consisting of over 150 organizations from 28 countries, from which the following potential stakeholders have been identified and are planned to be approached:

Companies and SMEs

1. Atlantis Engineering SA
2. Audi AG
3. Boehringer Ingelheim GmbH
4. Brainport Industries Cooperatie U.A.
5. The Ego Company GmbH
6. ENGIE – Direction de la Recherche
7. Engineering Ingegneria Informatica Spa
8. Fujitsu Limited
9. Huawei Technologics Co. Ltd.
10. IAV GmbH Ingenieurgesellschaft Auto und Verkehr
11. Mercedes-Benz Group AG

12. REWE digital GmbH
13. Robot Revolution & Industrial IoT Initiative
14. Rockwood Quantum Ltd.
15. Salzgitter AG
16. Schaeffler AG
17. Siemens AG
18. Tata Steel IJmuiden B.V.
19. ThyssenKrupp Services GmbH
20. VDMA e.V.
21. Volkswagen AG

From Research and NGOs

1. Asociacion Investigacion Metalurgica Noroeste (AIMEN)
2. Force Technology
3. IMT - Institut Mines-Télécom
4. Industry Innovation Cluster
5. INESC TEC
6. Irish Manufacturing Research
7. Technology Industries Finland
8. VTT TechRes Centre of Finland Ltd.

5.3.2 Stakeholders engagement methods

After having successfully identified the stakeholders that are relevant to the project, it is important to choose the adequate engagement methods, for example:

- Surveys and questionnaires: This tool helps gathering input from several stakeholders on the project´s value and relevance.
- Interviews: One on one interviews with stakeholders can help gather in-depth insights and opinions on the project.
- Workshops and conferences: RE4DY will host and participate in workshops and conferences that will bring stakeholders together for collaborative discussions, networking, and knowledge sharing.
- Social media and online presence: RE4DY´s public relationship´s office will be the Digital Factory Alliance[1]. They are responsible for the project´s online presence, such as social media channels, online conferences, and newsletters.

[1] https://digitalfactoryalliance.eu/

- Participatory action research: It can be beneficial for RE4DY to involve stakeholders in the research process itself. This would allow them to actively contribute to problem-solving and decision-making.
- Hackathons and challenges: Hackathon's and challenges will be arranged around the RE4DY self-service analytics marketplace to leverage highly innovative engineering, commissioning & operation of connected manufacturing & supply chain networks and active resiliency strategies that can expand the set of services already.

It is also important to consider that in many cases, the chosen engagement methods will have to be tailored to the targeted stakeholder or adapted according to several factors.

5.3.3 Monitoring and evaluation

The third step for a successful stakeholder analysis is monitoring and evaluation. First, it is important to revisit the information on the identified stakeholders.

All the project's stakeholders will be recorded in the Stakeholder tracker, which will compile all the organizations and individuals that are relevant to the project, to which degree they have an impact on it and what the actions are in order to keep them engaged.

The stakeholders will not only be recorded in this document but will be evaluated based on the Power-Interest Matrix, which will determine the importance of a stakeholder based on the impact power they have on the project and the interest they show. The Power-Interest Matrix, also known as the Stakeholder Analysis Matrix, is a strategic tool used in business analysis to assess and categorize stakeholders based on their level of power and interest in a project. This matrix helps organizations prioritize and tailor their communication and engagement strategies for different stakeholder groups. An overview of the four quadrants in Power-Interest Matrix:

- Keep Satisfied: High power and low interest. The goal is to keep the stakeholder satisfied and potentially make him/her/it a stakeholder of category II.
- Manage Closely: High power and high interest. These are the stakeholders that must be managed closely and who are in the focus of the project. They must be transformed into customers of RE4DY.
- Monitor: Low power and low interest. RE4DY must keep an eye on this stakeholder group in order to see if a transition of either Power or Interest is happening or even contribute to such a transition in case intended.
- Keep Informed: Low power and high interest. RE4DY must keep these stakeholders informed either personally or more preferably via standard communication channels, such as the project webpage or blog, Twitter, and LinkedIn, to reduce efforts.

P O W E R	I. Keep Satisfied	II. Manage Closely
	III. Monitor	IV. Keep Informed
	INTEREST	

Figure 30:RE4DY Stakeholder Matrix

This evaluation will help the consortium partners bring all stakeholders into different categories and then act based on this groups. Not only that, but after evaluating and categorizing a stakeholder, it is important to monitor its status.

The power and interest of a stakeholder, especially the latter, can change depending on the engagement strategies that are put in place, so it is important to monitor and document it. This will provide a clear outlook and will ease decision making when it comes to choosing follow-up actions.

6 RE4DY business development

Business development for RE4DY involves a strategic and systematic approach to foster growth and successful exploitation of project outcomes. Below are key components and considerations for the business development of RE4DY:

- Market Analysis and Research: Conduct thorough market research to identify industries and sectors that align with the goals of RE4DY. This includes understanding the needs, challenges, and trends in these industries.
- Value Proposition Refinement: Refine the value propositions of RE4DY based on the insights gained from market analysis. Tailor the project's offerings to address the specific needs and pain points of the identified target audience within the manufacturing and industrial sectors.
- Technology Transfer and Adoption: Develop models for transferring RE4DY technologies and solutions to industries. Promote the adoption of project outcomes by showcasing their practical applications and benefits for enhancing sustainability and efficiency.
- User Engagement and Feedback: Continuous engagement with end-users and stakeholders. Gather feedback on the usability and effectiveness of RE4DY solutions, allowing for iterative improvements and ensuring alignment with the end-user´s expectations.
- Dissemination and Communication: Develop a comprehensive communication strategy to disseminate information about RE4DY. Utilize various channels, including webinars, conferences, publications, and social media, to effectively reach target audiences and create awareness about the project.
- Business Model Optimization: Optimize the business model based on feedback, changing market dynamics, and the evolving needs of stakeholders. Ensure that the elements of the business model align with the project's long-term objectives.
- Financial Sustainability: Explore and diversify the financial aspects, to contribute to the financial sustainability of RE4DY beyond the project duration.

In summary, RE4DY's business development will be an adaptive process, informed by a deep understanding of the market and partner needs, stakeholder engagement, and strategic adjustments will contribute to the project's successful business development and long-term impact.

6.1 RE4DY extroversion

6.1.1 Synergies with external communities & projects

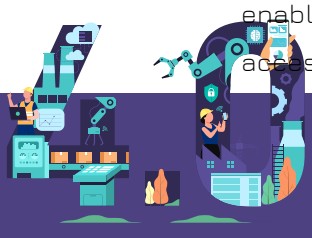
The exploration of synergies with external communities and projects is an aspect of developing the RE4DY business model. This process involves identifying, collaborating, and aligning efforts with other initiatives in related domains to enhance the project's impact, foster innovation, and ensure the sustainability of its outcomes. The insights gained by these endeavor's will be leveraged to support RE4DY business model and its components. In essence, the insights gained will be used in optimizing various facets of the RE4DY business model, ensuring that it is well-informed, adaptive, and positioned for success in the dynamic landscape of industrial data spaces and circular economy solutions.

6.2RE4DY business model

A business model encompasses the core aspects of a business, guiding its strategy and operations. Understanding the components of a business model is crucial for designing a sustainable and successful venture. In the context of RE4DY, a business model will be developed and implemented as tool to interpret the exploitation plan. The business model will be assessed with the stakeholders from the different phases of the RE4DY chain , in order to reach the final business plan that will ensure the successful exploitation of RE4DY results and its continuity post-project. To this end, the examination of existing developments and models within the industrial data space ecosystem will be considered. In essence, this examination will aim to identify the current landscape, serving as the foundation for developing the business model for the RE4DY project. By delving into the existing business models and initiatives within the Industrial Data Spaces domain, the RE4DY project will leverage the collective knowledge and experiences, to develop a robust, effective, and innovative business model that addresses the unique challenges and opportunities in the realm of industrial data exploitation.

In today's data-driven environment, different ways of doing business with data have emerged. These are Data as a Product (DaaP), Data as a Service (DaaS), and Data Spaces. To provide a clear understanding of these terms we present a comparison on the concepts most associated with data commercialization, while DaaP and Data Spaces are mainly addressed by RE4DY:

- Data spaces Data Spaces are decentralized and federated IT ecosystems that enable data sharing. Within these ecosystems, data from different sources is made accessible from data owners to data users for several purposes. Data Spaces are



based on several standards, such as the IDS standard, which facilitates, secure, sovereign, and interoperable data exchange in all domains, including industrial settings. As described by the Data Spaces Support Centre (DSSC) a data space is a distributed system defined by a governance framework that enables secure and trustworthy data transactions between participants while supporting trust and data sovereignty. A data space is implemented by one or more infrastructures and enables one or more use cases.

- Data as a Product (DaaP): In the Data as a Product model, the focus is on treating data as a standalone product.
- Data as Service (DaaS): Data as a service (DaaS) is a business model that offers data on demand and regardless of the consumer's location or infrastructure. To enable DaaS, organizations provide cloud-based software for analyzing and managing the accessed data.

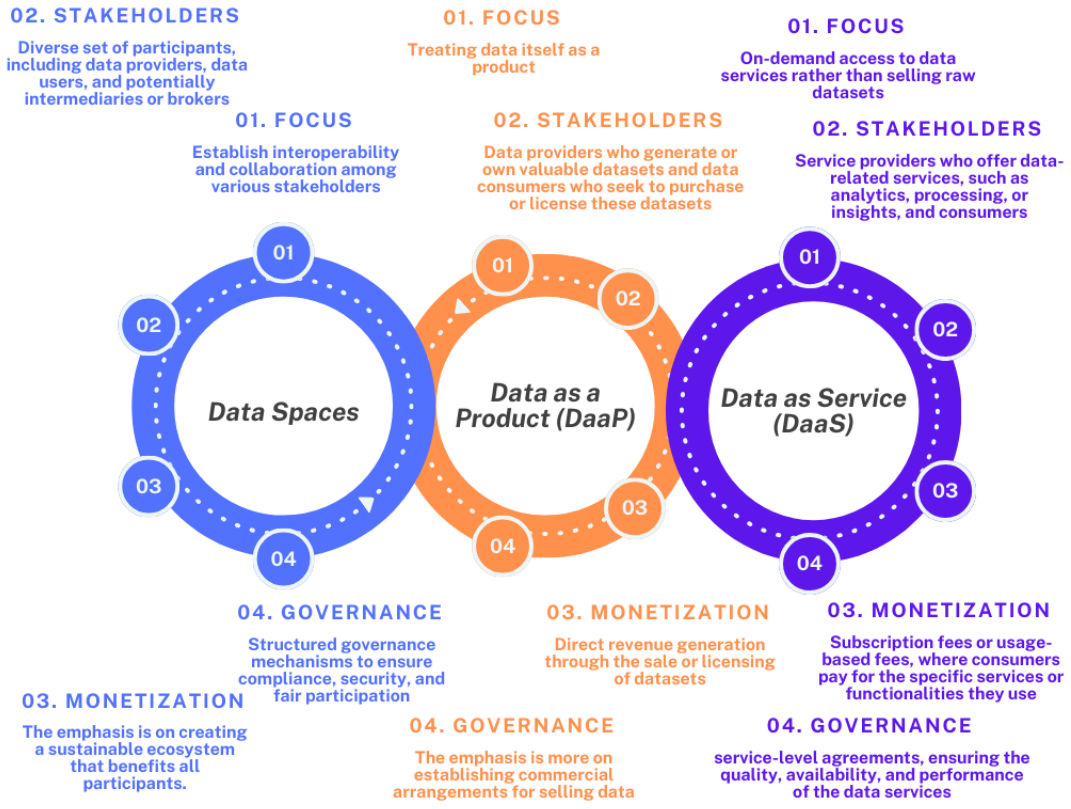
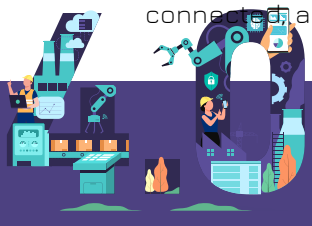


Figure 31: Data Spaces vs DaaP vs DaaS business model elements

In the next section, we examine the domains considered by RE4DY that will be further developed to shape the final business model for the project. The concept of "Data as a Product" is promoted to facilitate the implementation of digital continuity across various digital aspects such as digital threads, data spaces, digital twin, and AI and ML Data pipelines. Data as a Product aligns with the broader project mission of building resilient, connected, and competitive digital value networks for the European industry, suggesting



a practical and integrated approach for managing the lifecycle of data that goes beyond a service-oriented model (Data as a Service).

6.2.1 Knowledge on Industrial Data Spaces

The Fourth Industrial Revolution relies on data and information as its fundamental raw materials, serving as the cornerstone for innovative business models, value creation, and business expansion. However, to unlock the full potential of their data, organizations must strategically connect information across different companies and industries. One secure method for exchanging data is through the use of Industrial Data Spaces. The barriers to entry may be low, but companies looking to derive value from their own and others' data must invest in technology and innovation. It is crucial for each company to develop governance structure for effective data management and integrate the data strategy in the overall business strategy. The primary barriers are the lack of support for data exchange with other companies through traditional platforms due to the concern that sensitive data and business secrets might be exposed. This concern is particularly pronounced among security-sensitive companies actively engaged in cybersecurity. According to a survey from PWC, the organizations that appear to be more cautious about these issues include technology, IT, and communication companies, as well as governmental institutions, whereas manufacturing companies show a lower-than-average representation. Today, a significant majority of companies, specifically three out of four, are actively engaged in the exchange of data with customers, suppliers, and other external entities. Moreover, inter-company data exchange is substantial important in processes within manufacturing and supply chain management. This includes the sharing of crucial information such as raw material volumes, inventory records, indicating a growing trend toward collaborative data practices that enhance operational efficiency and connectivity across business networks.

The current challenge in establishing harmonized data spaces is more about coordination and scalability than a lack of technology. The soft infrastructure can only be achieved through effective coordination, and successful coordination relies on good governance.

Good governance in this context involves striking a balance among the interests, input, and energy of both private and public actors. This balance is essential for ensuring long-term innovation and continuity. In this context, the published Data Governance Act (DGA) serves as a governance framework for the establishment of European data spaces. Within the DGA, a data intermediary is a term encompassing parties such as brokers, marketplace operators, or facilitators responsible for organizing the sharing and exchange of data among all actors, including both organizations and individuals.

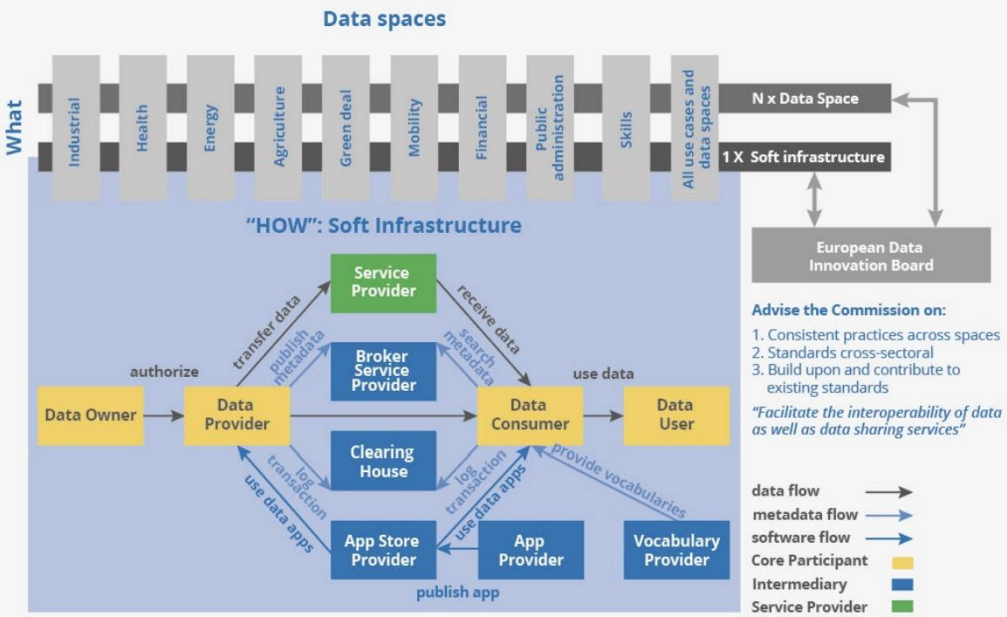
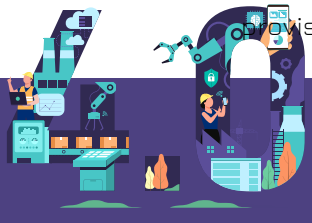


Figure 32: Overview of data governance act

In the context of a data space, various roles exist. A critical distinction is made between 'adhering' and 'certified' parties[¡Error! Marcador no definido.]. Relevant models will exist on two levels , for individual actors (adhering or certified) and the creation and maintenance of the soft infrastructure:

- Adhering Parties: These are the 'users' of the data space, which can include businesses, governments, or individual and in practical terms, adhering typically comply with the terms and conditions set by their IT providers. Business models for monetizing data exchange among adhering parties can be categorized into internal and external perspectives. Internally, models aim to derive value directly from data, such as gaining a competitive edge or minimizing business risks. Externally, models focus on creating value for customers through raw data or value-added services based on data insights, with monetization occurring through direct sales or indirect methods. All stages of data exploitation, including raw data, correlation, and analytics, can be monetized.
- Certified Parties: Certified parties fulfill facilitating roles in the data (sharing) process, enabling adhering parties to 'use' the data space. This means that any party that assumes a role such as data broker, data market player, e-commerce platform, software vendor, or data collective will need to be certified. This certification (e.g. IHAN, IDS, Data Sharing Coalition, iSHARE and MyData Operators extends to various entities. This certification extends to various entities, such as data brokers, data market players, e-commerce platforms, software vendors, or data collectives. These certified parties are expected to offer services like identity provisioning, authorization registry management, functional testing, security



testing, etc. For certified parties and data intermediaries, business models are oriented toward service provision rather than profiting directly from data, as stipulated in the Data Governance Act (DGA).

Participants involved in providing or consuming data, along with software vendors, can implement their solutions based on the framework. The business model revolves around collectively funding the creation and ongoing maintenance of data spaces, without a profit motive. The success of this model relies on widespread adoption of European data spaces and their significance to participants, making it easier for the participants themselves to fund these efforts[¡Error! Marcador no definido.]. According to Data Spaces support center a business model comprise elements that collectively align with the data spaces objectives and support sustainability, growth and scalability. When developing relevant business models, the following elements should be considered :

- Participants: Participants with similar needs and objectives may be grouped into segments, such as data providers, data users or rights holders and refers to the entities involved in developing and implementing use cases, essentially serving as its 'customers.'
- Value propositions for both sides: From the perspective of a data space business model, the data space conditions must be attractive for both the data rights holders and data users. Developing value propositions for various stakeholders becomes a key strategy for the success of the business model.
- Data Space Revenue Model: Consider different revenue mechanisms to ensure financial sustainability, by Identifying income sources, participant fees (subscription, membership, or transaction fees), and other external revenue and funding streams.
- Data Space Cost Model: The revenue model must cover all costs for the data space to achieve self-sustainability, encompasses development costs, operational costs of enabling services, and governance-related expenses.
- Organization and Operations: The mode of organizing operations is a crucial aspect of the data space business mode. Involves decisions on whether enabling services are managed in-house or outsourced to service providers, impacting the data space's costs.

According to Bitkom , a member of the Gaia-X European Association for Data and Cloud AISBL, data ecosystem encompasses a range of services designed to facilitate different stages of the data lifecycle:

- Preliminary services: These services are involved in the generation and preparation of data for sharing within a data space, ensuring the proper format with the data space requirements.

- Processing services: These services operate after the data has been received, to leveraging shared data to provide added value and tangible results.

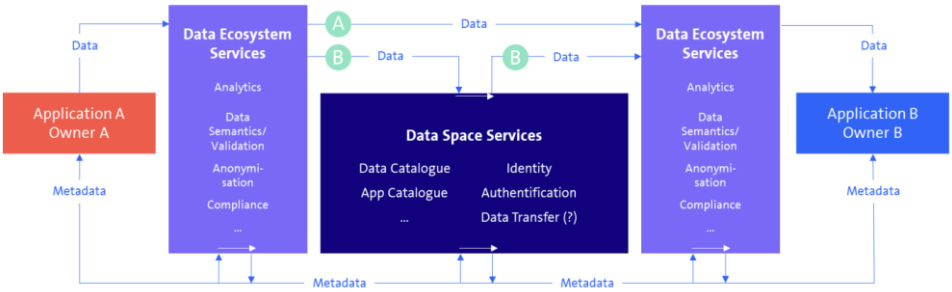


Figure 33: Data Space Flowchart

The introduction of a data space transforms the landscape of data sharing by promoting ad-hoc collaboration among a diverse array of actors. The reduction of search and transaction costs, along with scalability and collaboration, distinguishes the data space model from traditional data exchange approaches, that involve licensing of data or commissioned data processing between two or a few partners[¡Error! Marcador no definido.].

6.2.2 Knowledge on Data as a product (DaaP) business model

As technology advances, many organizations are adopting business models that rely on data. These models help organizations to leverage the large amount of data and to fully benefit from these models, companies need to invest in the right technology to gather and analyze data efficiently and use advanced tools like artificial intelligence and machine learning to get valuable insights from the data. In parallel, it is important to establish practices for handling data, such as having clear privacy policies and robust security measures, which all are addressed by RE4DY developments. In the landscape of data-driven strategies, two concepts stand out: "Data Product" and "Data as a Product" (DaaP). These approaches offer distinct perspectives on harnessing data for business value, however DaaP is the main concept enabled by RE4DY. To distinguish between the models:

- A data product is essentially a product or service designed around utilizing data to offer insights, analysis, or value to users or customers. It encompasses the entire process of collecting, processing, analyzing, and presenting data in a manner that is both useful and actionable. Some common examples of data products include analytics dashboards, recommendation engines, data visualizations, and predictive models.
- On the other hand, Data as a Product (DaaP) takes the concept further by treating data itself as a valuable product. In this approach, data is viewed as a commodity with

value, and organizations focus on packaging, marketing, and monetizing their data assets. This means that, similar to traditional products, data can be bought sold, or exchanged as an independent entity,

DATA PRODUCT	vs	DATA AS A PRODUCT
Utilizing data to deliver value-added services or insights		Focuses on the data itself, rather than utilizing it to provide services or insights
Involve various data processing techniques		Establishing data governance policies, and managing data sharing or licensing agreements
Address specific business needs or solve particular problems		Can be sold to external parties or utilized within an organization for various purposes
Product Managers Data Scientists/Analysts Developers/Engineers Business Analysts		Data Managers/Owners Data Scientists/Analysts Business Development/Sales Legal/Compliance Teams

Figure 34: Data Product vs Data as a product

A theoretical framework proposed by the academia for designing data-driven business models based on data collected is the Service/Technology/Organization and Finance (STOF) model . This framework serves as a guide for delivering a service, outlining the service definition, its intended value for the target audience, revenue sources, and presenting a structure for service delivery. It encompasses a description of the necessary resources, along with the organizational and financial agreements among the involved business actors. This includes detailing their roles and delineating how costs and revenues are distributed among these business actors.

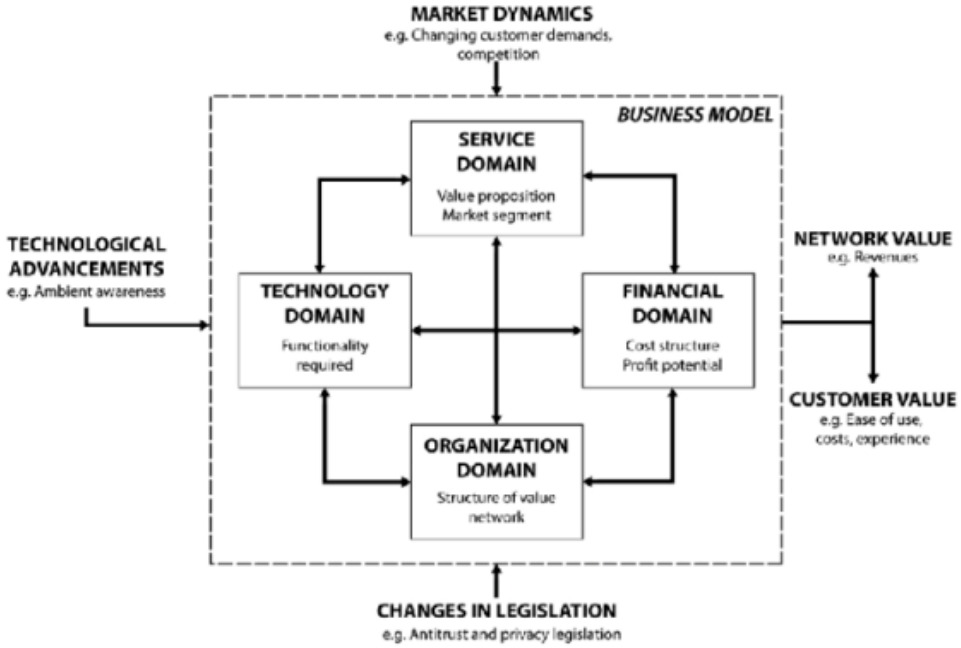


Figure 35: STOF business model

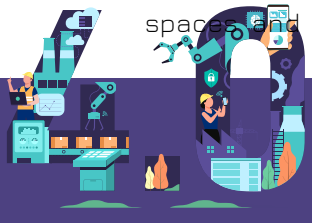
Based on literature research, another interesting way to define business models related to data monetization are as follows:

- Data users: Entities which use data to form strategies and build better products. The business model of data users centers around extracting actionable insights from the data they acquire.

Type	Functions
Data users	Using data to inform decision making
Data Suppliers	Gathering, aggregating, and selling data
Data facilitators	Supplying infrastructure and tools to collect, store and analyze data

- Data Suppliers: Entities which are primarily involved in the trading of data. The business model of such companies revolves around the provision of data in diverse formats and often curate datasets valuable to other businesses.
- Data Facilitators: Entities involved in providing data infrastructure, analytics, and consultancy , leading to the formation of another business model which focuses on providing data collection and handling tools like server's data collection, analysis and visualization software, database management software, encryption, data protection technology, and many other data related hardware and software. The focus on providing services and tools to ease the data related processes.

In summary, the landscape of data-driven business models is vast, encompassing data spaces and Data as a Product. The success of these models depends on effective



governance, coordination, and creating value for participants. The next step involves the development of the specific business model, leveraging the knowledge gathered on industrial data spaces and data as a product finding.

Table 10: Data monetization business model

6.2.3 RE4DY Business Model Canvas

The Business Model Canvas (BMC) is a strategic management tool that provides a holistic and visual representation of a business's key components. Developed by Alexander Osterwalder and Yves Pigneur, the BMC is widely used for its simplicity and effectiveness in describing and analyzing business models. It provides a structured framework that enables individuals and teams to comprehensively describe, design and, invent, or pivot their business model, whether applied to startups, existing businesses, or innovative projects, such as RE4DY. The framework consists of nine building blocks, each capturing a critical aspect of a business. In the context of the RE4DY project, the BMC framework will have a central role in articulating the project's exploitation strategy, especially in terms of how the results will deliver value, generate value, and reach intended target stakeholders.

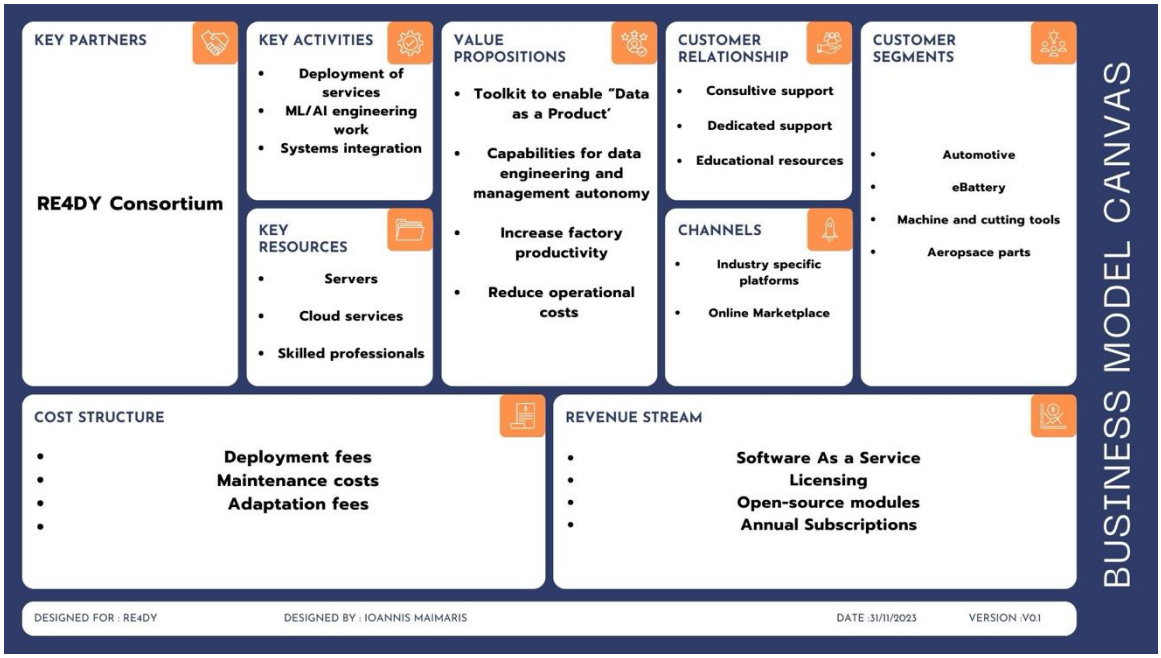
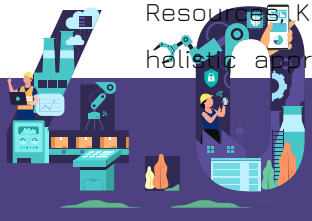


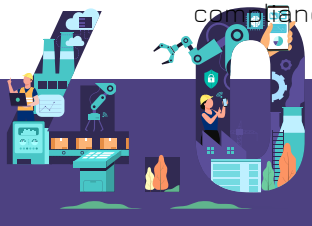
Table 11: RE4DY Business model canvas

The primary aim within the business model is to deliver a pragmatic and effective business exploitation strategy. Through its nine essential building blocks, including Customer Segments, Value Propositions, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partnerships, and Cost Structure, the BMC encourages a holistic approach to business strategy. It facilitates strategic thinking, encourages



collaboration, and supports decision-making by providing a visual representation of how different aspects of a business interconnect and contribute to overall success.

- Customer Segments: This section identifies the primary target segments for the post-project phase of RE4DY. The understanding of adhering and certified parties within the ecosystem helps identify the target segments for RE4DY. These may include businesses, governments, and individuals actively participating in data spaces. The target manufacturing sectors within EU industry are comprised primarily by the four-use case market (eBattery and mega-factories, Automotive sector, Aeronautics parts sector, machine and cutting tools industry).
- Value Proposition: The unique value propositions for RE4DY will be designed in cooperation with the partners to communicate the unique value proposition that the projects product, services, and other results will offer to its target stakeholders. Developing value propositions is identified as a key strategy for achieving success in the business model as they must be attractive for both the data rights holders and data users.
- Channels: RE4DY partners will leverage existing networks and partnerships and synergies with other communities and stakeholders. Channels will include remote engagement through webinars, direct engagement within owned networks, and indirect engagement through partner networks.
- Customer Relationships: Various customer support levels will be included especially for the business exploitation results. Understanding the different roles (users, suppliers, facilitators) informs the development of tailored customer relationships, addressing the distinct needs of each category.
- Revenue Streams: Revenue streams will be identified for the commercial results including Software as a Service (SaaS) subscriptions, annual software subscriptions, monthly service subscriptions, direct licensing, expert analysis or contract research fees, and deployment & adaptation fees. Monetization strategies, such as SaaS subscriptions and licensing, are informed by the DaaP model, outlining tangible paths for generating revenue
- Key Resources: Essential resources for RE4DY will encompass physical assets (sensors, data acquisition systems), human resources (software engineers, data scientists) and other financial resources (marketing and communications activities, legal support). Human and physical resources required for secure data exchange and governance are identified, ensuring that the project has the necessary assets.
- Key Activities: Core activities to develop further and implement and the value propositions post-project will be assessed, including activities related to the development, implementation, and operation of secure data spaces are outlined, In compliance with the IDS standard.



- Key Partnerships: Strategic collaborations involve all technical partners engaged in developing solutions, will be defined. Partnerships with entities facilitating data monetization and value-added services will be aligned with the DaaP model.
- Cost Structure: Cost drivers include expenses for human resources, costs related to hardware and software maintenance, and expenditures related to activities such as marketing and legal support will also be considered. Costs associated with governance, secure data exchange, and infrastructure maintenance will be considered within the overall cost structure, along with expenses related to monetizing data as a product are factored into the cost model.

The information provided in the previous section for Industrial Data Spaces distinguishes between two critical roles within the data space ecosystem: adhering parties, representing users complying with terms and conditions, and certified parties, fulfilling facilitating roles in the data-sharing process. This dual-party system forms the foundation for effective data management and exchange, highlighting the need for good governance and a balance of interests among private and public actors. The exploration of the DaaP Business Model delves into the concept of treating data itself as a valuable product. This approach transcends goes beyond traditional data utilization models, focusing on data as a product and its potential for monetization. Section 6.2 introduces various business model concepts associated with data monetization, categorizing them into three distinct roles; Data Users, utilizing data for decision-making; Data Suppliers, involved in gathering, aggregating, and sellig data; and Data Facilitators, supplying infrastructure and tools for collecting, storing, and analyzing data. The insights garnered from the research on Industrial Data Spaces and the exploration of the DaaP Business Model are integral components that will be incorporated into the development of the Business Model for the RE4DY project. The methodology of the Business Model Canvas will be tailored based on the project's developments and the outcomes of the joint exploitation strategy. This will esquire the alignment of the Business Model with the desired exploitation strategy of the consortium. The final version of the model will ensure that the canvas reflects the specific goals, objectives, and collaborative approach envisioned by the consortium for the successful implementation and commercialization of the project results.

7 Conclusions

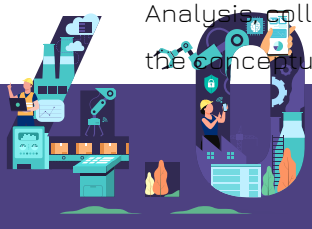
Work Package 6 is strategically positioned to achieve two critical objectives for RE4DY: 1) raising awareness and maximizing visibility of the project, and 2) developing a compelling business model to sustain RE4DY developments and maximize its impact . By presenting a clear understanding of each market use case, we aim to equip stakeholders, and decision-makers with valuable insights. This knowledge not only facilitates an understanding of the current market situation but also serves as a foundation for strategic planning of the project next steps.

The e-battery market is experiencing remarkable growth led by the electric vehicle sector and lithium-ion batteries demand. Government commitments, EV adoption incentives, and renewable energy trends drive the market. Challenges include energy density limitations and raw material price volatility. The automotive industry stands as a crucial driver of economic growth in Europe and globally with a diverse manufacturing ecosystem, Europe has a significant role in shaping the automotive landscape while the market is poised for the recent trends in the European Union's car market highlight a sustained expansion, driven by a growing preference for electric and hybrid vehicles. The automotive sector remains a key contributor to the European economy and substantial R&D spending.

The aerospace parts manufacturing market in Europe plays a pivotal role in the global aerospace industry, encompassing the production of critical components for aircraft, engines, avionics, and cabin interiors is subject to regulations, emphasizing safety and quality standards set by both national and international bodies. The sector's multi-phased production process involves advanced technologies and precision machinery to ensure the creation of high-quality and secure aerospace components.

The machine tools industry is witnessing substantial growth, driven by technological advancements, increased adoption of advanced manufacturing techniques, and a focus on precision and efficiency. The industry displays a fragmented landscape with global players and regional competition, particularly in key hubs such as China, Germany, Japan, and Italy, while companies are actively engaging in partnerships, collaborations, and mergers to enhance their market presence and drive innovation.

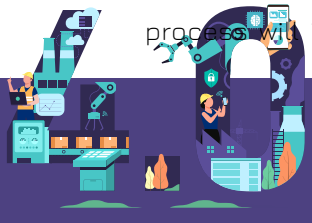
In addition, the technological landscape has been assessed to understand the significance of the involved technological pillars and the impact that the projects development can bring post project. The chosen methodologies and tools, including Market Analysis, External Environmental Analysis, Data Gathering Tools, Workshops, Surveys/Questionnaires, Value Network Tool, Business Model Canvas, and Cost-Benefit Analysis collectively form a comprehensive toolkit. These tools will guide the project from the conceptualization of RE4DY to the generation of tangible results.



The work plan, organized into three phases—Market Study, Exploitation Plan, and Business Model and Knowledge Transfer reflects a systematic progression. The exploitation objectives linked to Task 6.3 encompass a well-structured work plan that addresses key pillars, including commercial and non-commercial exploitation, joint exploitation routes, intellectual property (IP) strategy, business model development, and a roadmap to achieve Technology Readiness Level 9 (TRL9) and commercialization. The systematic identification and documentation of exploitable outcomes, as presented in the initial table, reflect the consortium's commitment to a structured approach in evaluating individual results throughout the project lifecycle. The diverse range of exploitable results (spanning industrial security, decentralized data management, manufacturing dataspace, AI models, federated learning, and more) showcases the project's multifaceted contributions.

As the project progresses, the consortium will update this list, ensuring an adaptive strategy for maximizing the impact of the RE4DY project. The diverse mix of IPR mechanisms chosen for individual exploitable results, including open-source licenses, patents, trademarks, and licensing agreements, reflects a strategic and tailored approach. The ongoing collaboration among partners will further refine the IPR management plan, aligning it with the technical specifications of the results. The joint ownership will be collaboratively developed and defined by the consortium as the project progresses within the joint exploitation scenarios. Partners within the consortium will actively engage at a later stage in discussions to explore various joint exploitation scenarios. The objective is to achieve consensus on the final exploitation plan, considering factors such as the nature of project outcomes, partners' intentions for their results, technical aspects of developments, and alignment with current industry and market needs. The BMC methodology will be tailored based on project developments and the outcomes of the joint exploitation strategy, to ensure alignment with the consortium's goals, objectives, and collaborative approach for the successful implementation and commercialization of project results. The final version of the model will reflect the vision outlined by the consortium. The stakeholder engagement strategy for RE4DY is a crucial component in ensuring the success of the project by aligning outcomes with the needs of the manufacturing sector and broader EU goals.

The identification of diverse stakeholder groups and the establishment of clear objectives for each group lay the foundation for effective engagement. The stakeholder analysis incorporates a Power-Interest Matrix to categorize stakeholders into different groups, guiding the level of engagement required. Monitoring and evaluation are integral to the strategy, ensuring ongoing assessment of stakeholder dynamics, project requirements, and external factors. The development and implementation of a business model are crucial aspects of the RE4DY project, serving as tools to interpret the exploitation plan. This process will involve engaging stakeholders from various phases of the RE4DY chain to



ensure a successful venture. The exploration of Data Space business models and DaaP business models is essential, based on the examination of existing developments and models within the industrial data space ecosystem. The strategic exchange of data through secure frameworks like the IDS Standard is essential for unlocking its full potential, driving innovation, and fostering collaboration across industries. On the other hand, the emergence of the Data as a Product (DaaP) business model underscores the evolving landscape where data itself is treated as a valuable commodity.

The business development efforts for RE4DY should be characterized by continuous learning, iterative improvements, and a commitment to creating lasting value for industries, stakeholders, and the environment. The methodology of the Business Model Canvas will be tailored based on project developments and the outcomes of the joint exploitation strategy. This alignment will ensure that the canvas reflects the specific goals, objectives, and collaborative approach envisioned by the consortium for the successful implementation and commercialization of the project results. The final version of the model will be a dynamic tool, evolving with the project's progress and ensuring a strategic approach for RE4DY's sustainable growth and impact.

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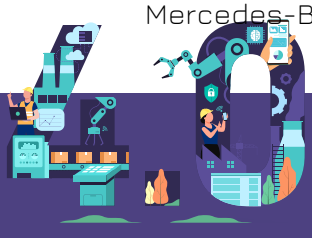

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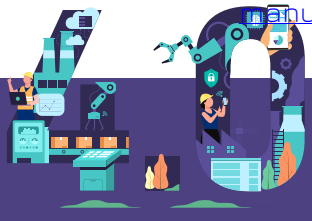

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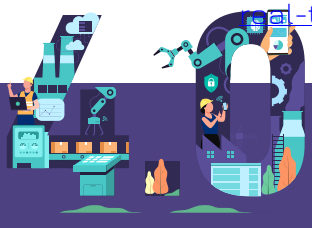

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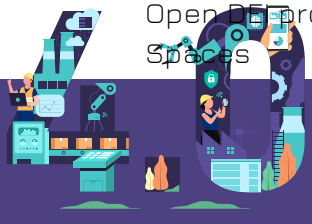

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