European Data Market
SMART 2013/0063
D 3.10

Industrial Data Platforms – Key Enablers of Industry Digitization

28th July 2016

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Deliverable	D 3.10 Quarterly Stories – Story 10
Date of delivery	28th July 2016
Version	2.0
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Contract ref.	N. 30-CE-0599839/00-39

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Executive Summary

Advances in digital technologies are rapidly changing the way products and services are being designed, produced and marketed bringing about a profound transformation within the manufacturing industry and, ultimately, across all industry sectors. "Third-Platform"[1] technologies are creating new industrial patterns while deeply impacting the existing industry value chains. These transformations have one thing in common – the role of data and the way companies and other economic actors are able to generate, use, and exchange them.

The concept of industrial data platform serves precisely the need of establishing trusted networks where data can be transferred, accessed, and used in a secure mode. Industrial data platforms can therefore be defined as virtual environments facilitating the exchange and connection of data between different organizations through a shared reference architecture and common governance rules. By linking different actors who are interested in sharing information in the form of data, industrial data platforms constitute a composite business ecosystem combining players from disparate backgrounds, thus fostering the creation of new data-driven services and innovative business processes.

Our research presents a diversified picture of actual, initial implementations of industrial data platforms. On the one hand, industrial data platforms may take the form of open, multi-company-led environments that are conceived to meet the requirements of a wide community of industry users from different industry sectors; on the other hand, single-company initiatives are emerging where an individual organization (usually a prominent ICT player or a leading industry actor) establishes its own platform and opens it to other companies for commercial purposes and primarily within the boundaries of a specific industry sector.

Whatever the form that industrial data platforms may take, companies are already starting to realize the advantages of this new model of exchanging data in terms of both productivity and efficiency improvements. IDC Manufacturing Insights, for example, foresees that by 2019, 75% of manufacturing value chains in EMEA will undergo an operating model transformation with digitally connected processes that will improve responsiveness and productivity by 15% on average. Again both Boston Consulting Group (BCG) and PwC believe that digitization and interconnection of products and services will also allow companies to gain additional revenues of 2% to 3% per year on average. If confirmed, these gains could amount to approximately €30 billion per year for Germany's industry alone and to €130 billion per year for the European industry as a whole.

Overall, we observed that companies tend to privilege data platforms that allow to retain a certain degree of control and flexibility on their actual business and technical requirements. This seems to give the open, multi-company-led model of data platforms some sort of lead vis-à-vis the competing model of proprietary data platforms. Indeed, US manufacturing companies are already seeking to break into these closed-loop solutions via the channel of standardization, in much the same way as the Internet Protocol swept away everything in its path in the 1990s.

European policy-makers should therefore focus their attention on measures accompanying the creation of data governance models and other framework conditions facilitating the emergence of open data platforms. In particular, achieving critical mass would be fundamental for open platforms to become recognized and successful and a wide range of industry actors (including third party developers, suppliers and users) should be encouraged to join the platforms and build applications and services that run on them. To this aim, legal aspects related to data transfer and data use, as well as implications emerging from data ownership and control and close cooperation with international standardization bodies, should be duly considered to reduce barriers and risks and encourage more users to embrace the open data platform model.

[1] *IDC's definition of Third Platform Technologies can be found here, among other sources: http://www.idc.com/prodserv/3rd-platform/*

1 Introduction

1.1 Main Objectives and Scope

1.1.1 Objectives

This document is one of a series of in-depth analysis focusing on the development of the data-driven economy in Europe based on specific case studies by sector and/or by technology. It constitutes the deliverable D3.10 of the study "European Data market", SMART 2013/0036 entrusted to IDC and Open Evidence by the European Commission, DG Connect, Unit G3 – Data Value Chain.

The main objective of this paper is to investigate the nascent phenomenon of industrial data platforms within the context of the European Data Market and its evolution towards an ever growing data-driven economy. In particular, the following pages will delve on the concept of industrial data platforms, their essential features and goals, and their link and positioning vis-à-vis the policy framework recently put forward by the European Commission to coordinate national and regional initiatives for digitizing the European industry[2].

Based on a series of selected, real-life case studies, this paper will also consider the potential role that industrial data platforms could play in sustaining the digitization of products and services across Europe so to reinforce the EU's competitiveness in digital technologies and ensure that every industry in Europe, regardless their specific sector, fully benefits from digital innovation.

1.1.2 Scope

This document examines the topic of industrial data platforms by exploring in detail the following aspects:

- The concept of industrial data platform, its theoretical notion and its practical applications;
- The current development of industrial data platforms across Europe and worldwide – design, testing, prototyping, applications in practice;
- The key existing and potential actors involved in industrial data platforms and their actual and future roles;
- The main requirements addressed by industrial data platforms and the services they offer to meet these requirements;
- The governance models currently at play within industrial data platforms with specific focus on data use, exchange, control and ownership among the data platform members and between the data platform members and the outside world.

1.2 Why Industrial Data Platforms matter – Latest Policy Developments

Digitisation, i.e. the process of converting information into a digital format, lies at the core of the European Commission's strategic framework initiatives aimed at strengthening Europe's overall economic competitiveness. The third pillar of the Digital Single Market (DSM) strategy is specifically devoted to the economy and the society and has as its main purpose to "maximise the growth potential of the digital economy" by leveraging and promoting different technologies and actions, such as IoT, cloud computing, standards, skills and e-government. In this context, the European Commission has

[2] *"Digitazing european industry: Reaping the full benefits of aDigital Single Market", COM(2016) 180 final, April 2016*

recently taken further steps[3] to improve industry digitization and help coordinate national and regional initiatives and bring digital innovation to the industry.

While some of these steps are built around co-ordination and co-investing measures, others are specifically aimed at building digital industrial platforms by combining digital technologies (typically IoT, big data, cloud computing, artificial-intelligence and 3D printing) into integration platforms enabling interactions between several groups of economic actors and addressing cross-sectoral challenges. Among these platforms, data platforms feature a prominent role as they are based on the exploitation of the value of data and on their exchange across different sectors and among different stakeholders so to concretely support the growth of innovative data-driven business in Europe.

Recognizing the value of data, the European industry and the Commission have been encouraging close cooperation between universities/public research institutes and private partners, especially SMEs, on R&I across sectors through facilitated access to and transfer of knowledge and technology. In 2014, a contractual Public-Private Partnership (Big Data Value cPPP)[4] has been launched with the aim of developing a data community and encouraging exchange of best practices to share datasets and facilitate knowledge and technology transfers between data scientists, data protection and security experts and, ultimately, fostering cooperation among different European industry actors to support the uptake of data-driven business models by European industries.

The present-day emergence of industrial data platforms in Europe is therefore to be seen within the framework of this policy context. The following pages will take stock of some of the most significant industry data platforms initiatives that are currently being developed in Europe highlighting their common characteristics, their business drivers, their potential impacts and sketching out some additional considerations for future policy implications at regional, national and European level.

1.3 Methodology Note

The present report is the result of a mixed effort entailing both secondary and primary research activities. Extensive secondary research on available public sources (including EU legislation and policy documents), ICT vendors' and end-users' documents, specialized press and academic literature was undertaken to obtain a viable definition of industrial data platforms and identify some of Europe's most significant industrial data platform's initiatives.

In parallel, a series of in-depth, one-to-one interviews with representatives of some of the most relevant industry data platforms in Europe were conducted to collect empirical evidence, validate the information obtained through secondary research and pinpoint some of the most important features characterizing the emerging phenomenon of industry data platforms and its potential evolution over the next few years. More specifically, the study team carried out four in-depth interviews with:

- "Fraunhofer's Industrial Data Space e.V" – a multi-sectoral, multi-company, end-user-led initiative aimed at identifying and evaluating user requirements of industrial data platforms' participants;
- "Combient AB" – a Swedish-based, multi-company-led industrial data platform bringing together companies and organizations from a variety of different sectors with the objective to foster digital innovation and industrial internet, with specific attention to companies that are not "digital native";
- "SAP HANA Cloud Platform" – a vendor-driven, open platform-as-a-service providing in-memory database and application services through cloud computing;

[3] *"Digitalising European Industry – Reaping the Benefits of a Digital Single Market", April 2016, COM(2016) 180 final.*

[4] *"Towards a thriving data-driven economy", July 2014, COM(2014)442 final*

- "Siemens' Cloud-for-Industry initiative ("MindShpere")" – a vendor-driven, open ecosystem that industrial companies can use as the basis for their own digital services.

Each interview lasted approximately one hour and was based on a flexible interview guide to encourage an open and spontaneous discussion. The interviews served as a basis to build the real-life case-studies presented in section 3 of the present document.

1.4 The Structure of this Document

This paper is structured along four main sections:

- The first section introduces the key objectives of this story, its scope, a concise policy background, as well as methodological approach that was followed by the study team to conduct the research;
- The second section describes the phenomenon of industrial data platforms in detail – its definition, landscape, key features and its expected business and economic impacts;
- The third section features four real-life case-studies of industrial data platforms in Europe;
- The fourth section provides a set of concluding considerations around the overall phenomenon of industrial data platforms in Europe and its possible evolution in the near future.

2 Industrial Data Platforms: What They Are and What They Do

2.1 Industrial Data Platforms: Definition, Activities and Categories

2.1.1 The fundamental role of data

Advances in digital technologies are rapidly changing the way products and services are being designed, produced and marketed, thus bringing about a profound transformation within the manufacturing industry and, ultimately, across all industry sectors. "Third-Platform"[5] technologies such as Big Data/Analytics, Cloud Computing, Social Business solutions and Mobility solutions, fueled by data-driven "innovation accelerators" (such as IoT, Cognitive Systems, Robotics and 3D Printing), are creating new industrial patterns while deeply impacting the existing industry value chains.

These transformations have one thing in common – the role of data and the way companies and other economic actors are able to generate, use, and exchange them. Data-driven technologies, and their applications, are producing and processing vast amounts of data at a pace that was simply unimaginable until a few years ago; companies have started to leverage these data to devise innovative products and services based on new business models. At the same time, data themselves have become a product on their own and, as such, can be transferred and traded in newly emerged "data marketplaces". To be efficient, however, data exchanges, need to occur within a trusted and secure environment.

2.1.2 Definition and roles of Industrial Data Platforms

The idea of establishing a trusted network where data can be transferred, accessed, and used in a secure mode is therefore underpinning the very concept of industrial data platforms. These can be defined as **virtual environments facilitating the exchange and connection of data between different organizations through a shared reference architecture and common governance rules**. By linking different actors who are interested in sharing information in the form of data, industrial data platforms constitute a composite business ecosystem combining players from disparate backgrounds, thus fostering the creation of new data-driven services and innovative business processes.

Typically, industrial data platforms perform several services above and beyond facilitating the sheer data exchange between data providers and data users. In particular, industrial data platforms:

- *establish clear data governance rules* and *safeguard the principle of data sovereignty* by granting the data owners (which usually, but not always, coincide with data providers) the exclusive right of determining the terms and conditions of the use of the data provided;
- *deliver "brokerage" services* between data providers offering data and data users requesting data within the common environment. Whether embodied by a single organization or shared across more than one data platform's participants, the "broker" presides over different functions offered by data platforms, such as keeping the records of data transactions, performing search tasks, and facilitating ad-hoc agreements between data providers and data users, should these not be able to come to a common understanding about the provision and use of certain data.
- *provide access to an application layer* (through a series of shared Application Programme Interfaces – APIs) where data platform's participants may obtain and develop software to produce data-driven products and services.

[5] *IDC's definition of Third Platform Technologies can be found here, among other sources: http://www.idc.com/prodserv/3rd-platform/*

2.1.3 Industrial Data Platforms: Open model vs. Proprietary model

Still in its infancy phase, industrial data platforms are constantly evolving and may take different forms and shapes based, among other things, on the degree of openness that they grant, the business/operational model they adopt, the types of services they offer, and the governance model that they embrace. Our empirical research has unveiled two main types of data platforms:

- **Open, multi-company-led, user-driven industrial data platforms**, which are characterized by a bottom-up approach and are designed to meet the requirements of a wide range of end-users belonging to a specific industry sector or to several industry sectors. Truly open in their nature, these platforms are based on a decentralized governance approach, as well as on a distributed technical architecture, and are currently primarily oriented towards pre-competitive activities with the aim to identify and define the actual requirements of the user companies participating to the platform. In this type of platforms, no single company or platform participant plays a dominant role and no central authority is in charge of data management, nor is granted special supervisory functions. This is not to say that open platforms do not have "rules of the game" presiding over data use and data exchange. These rules exist but are commonly established by all participants and developed around the specific user requirements of all participants.
- **Proprietary, single-company-led, supply-driven industrial platforms**, which are developed and steered by an individual organization - usually an ICT vendor or a prominent industry player – for commercial purposes. Still open to the participation of companies and organizations from a multitude of sectors, these platforms are "owned" by a single company and follow a commercial rationale, with participants playing subscription fees based on the amount of data that they exchange and the services that they access to. Proprietary platforms tend to specialize and offer services around the knowledge-base of their owner (typically in automotive and transport equipment, manufacturing of machinery and equipment, manufacturing of computers and electronic components and other manufacturing areas). Unlike the open, multi-company-led data platforms, this type of platforms has a centralized data governance approach and a centralized architecture (although open to some degree of customization by the platform's participants through the sharing of APIs

The distinctive features of the open and proprietary data platform models are summarized in the table below.

Table 1 Types of Industrial Data Platforms and their distinctive features

	Open Industrial Data Platforms	**Proprietary Industrial Data Platform**
Leadership	Multi-company	Single-company
General Approach	Bottom-Up; User-Driven	Top-Down; Supply-Driven
Main purpose	Pre-competitive research; definition of user requirements	Commercial
Sector Specialization	Horizontal (in principle)	Vertical (in principle)
Data Governance	Decentralized	Centralized
Technical Architecture	Distributed	Centralized with varying degree of openness

Open, multi-company-led data platforms and proprietary, single-company-led data platforms represent the two ends of a theoretical continuum, whereas the reality is clearly characterized by a much higher degree of complexity. As described in the following paragraphs, the actual landscape of industrial data platforms presents a more variegated picture, with features pertaining to each of the two extremes often distributed along the full length of the continuum.

2.2 Industrial Data Platforms and the International Landscape

Industrial Data Platforms are the strong arm of digital innovation in industry as they allow for safe, trustable and efficient data exchange and use among different companies and organizations within the same industry sector or, indeed, across a wider spectrum of industry segments. Yet, their emergence would not have seen the day without the intervention of regional and national initiatives that were launched by Member States to help digitalizing the European industry. These initiatives vary significantly in form and content but have all in common the objective a setting and implementing an industry digitization programme to be carried out by concrete technology transfer projects over the medium to long term. Among the most prominent national initiatives in Europe it is worth mentioning:

- **Germany's "Industrie 4.0"** whose aim is to promote digital structural change and develop a consistent overall understanding of industry digitization in the country through dialogue with businesses, trade unions, science and government. The initiative draws up relevant recommendations for action and demonstrates with example applications how industrial manufacturing can be digitized successfully in practice.
- **France's "Industrie du Futur"** – a national alliance bringing together industrial businesses, professional associations, academia, and local authorities to develop regional digital platforms with the objective to promote digitalization in the manufacturing industry, with specific attention to small and medium businesses.
- **UK's "Catapult (High Value Manufacturing)"** – a network of seven centres, powered by the UK government, and offering manufacturing businesses of all sizes and from all sectors access to world-class equipment, expertise, research and collaborative opportunities.
- **Netherland's "Smart Industry"** – a government- and industry-led initiative setting a concrete action agenda and a "Technology Pact" among Dutch industry actors and academia to make the national industry more competitive thanks to digital technologies.
- **Spain's "Industria Connectada"** – a collaboration between Spain's Ministry of Industry, Energy and Tourism and some of the country's largest private companies (such as Indra, Banco Santander and Telefonica) establishing the main action lines, governance model, and concrete technology transfer projects to bring about Spain's industrial digital transformation.

Underneath this policy-level initiatives, a composite world of implementations and concrete actions in the form of industrial platforms have recently emerged across Europe. Most of these initiatives are geared towards the creation of a multi-sided environment enabling interactions between several groups of economic players. However, the actual objectives of these platforms may vary substantially.

- Some of them combine digital technologies to create integration platforms addressing sector-specific challenges such as standardization, interoperability and legal issues. As an example, **AUTOSAR**[6] (AUTomotive Open System ARchitecture) brings together some of the top global automotive manufacturers with the aim of establishing an open and standardized software architecture for automotive electronic control units. AEF- the Agricultural Industry Electronic Foundation – promotes **ISOBUS**[7], a universal protocol for electronic communication between

[6] http://www.autosar.org/
[7] http://www.aef-online.org/en/about-isobus/first-priority-isobus.html

implements, tractors and computers agreed by equipment manufacturers around the world to standardize the communications and data transfer between mobile systems (on tractors, for example) and office software used on the farm. **RAMI 4.0**[8] (Referenzarchitecturemodell Industrie 4.0) is a platform steered and by the German federal ministry for economic affairs and energy and the German ministry of education and research, in collaboration with high-ranking representatives from industry, science and the trade unions, to develop operational solutions in the areas of standardization and norms, security of networked systems, legal frameworks, research, and working arrangements.

- Other platforms work on the integration of digital technologies to develop sector-specific solutions in areas such as connected smart factories and connected automated driving. This is the case of a set of contractual PPPs funded under Horizon 2020 such as: **Factories of the Future (FoF)** – a platform setting a vision towards high added value manufacturing technologies for a clean, highly performing, environmental friendly and socially sustainable industry; **Sustainable Process Industry through Resource and energy Efficiency (SPIRE)** – a platform bringing together a widespread array of manufacturers from the cement, ceramics, chemical, minerals and other sectors to ensure the development of enabling technologies and best practices along all the stages of the existing value chains so to improve the efficiency of the industry; and **Bio-Based Industries (BBI)** – a joint undertaking to develop a sustainable and competitive bio-based industry through the development of new technologies exploiting biomass and replacing fossil-based inputs. BBI also aim developing business models that integrate economic actors along the whole value chain of bio-based industries, together with the setting up of biorefinery plants, and business models for bio-based materials, chemicals and fuels.

While certainly providing a shared environment for collaboration among vital industry stakeholders, the above platforms do not directly address the fundamental issue of data exchange and data use, which is the basis of digital transformation processes. To help establishing shared spaces for the safe and secure use and exchange of data, specific data platforms are being put in place. As described in the first part of this document, this concept is still in its infancy, however, a few significant examples in Europe and in the U.S. can be mentioned.

- **The Industrial Internet Consortium (IIC)** brings together more than 200 industry players across the world and among industries as varied as manufacturing, ICT, energy and transportation to accelerate the development, adoption and widespread use of Industrial Internet technologies. Founded in 2014 by some of the largest U.S. ICT companies (AT&T, Cisco, General Electric, IBM and Intel), it also features prominent European companies - such as SAP and Schneider Electrics - among its steering members. Specifically, IIC members are concerned with creating an ecosystem for data transfer, interoperability and security via reference architectures, security frameworks and open standards.
- In Germany, the **Industrial Data Space** initiative bringing together representatives from business, politics and research with the explicit aim to bring about and promote the development and use of a shared data platform at a European and Global level. Organized into a research project – funded buy the German Federal Ministry of Education and Research (BMBF), under the leadership of the Fraunhofer Institute for Intelligent Analysis and Information Systems (IAIS) – and a user association representing the specific requirements of industry users, the platform aims at establishing a network of trusted data through a distributed architecture, a decentralized data governance structure and a reliable network linking the Internet of Things with the world of smart services.
- In the Nordic countries, and specifically in Sweden, eleven companies from the manufacturing, ICT, and other services sectors, in combination with academia, have founded **Combient AB** – a Joint Venture with the aim of bringing digitalized innovation to the industry through the common development of best practices in the fields of innovation, automation and collaboration.

[8] http://www.plattform-i40.de/I40/Navigation/EN/ThePlatform/plattform.html

- In Spain, **Anella Industrial** (the Industry Ring initiative) has been launched in 2015 the objective to deploy cutting-edge infrastructure of telecommunications to bring innovative technology to the Catalan industry, with specific reference to non-digital-native companies that are struggling to reap the benefits of the ongoing industrial digitization.

In the third part of this report, we will provide a more detailed account of some of Europe's most significant industrial data platform initiatives – Fraunhofer's Industrial Data Space, Combient AB and Siemens' MindsSphere open industry cloud (based on SAP HANA cloud platform).

2.3 Business and Economic impacts

Industrial data platforms represent a key enabler of the digitalization of industry value chains, a process also called the advent of Industry 4.0 or the 4th industrial revolution. According to the second Industry 4.0 Global Expert Survey carried out by Mc Kinsey in January 2016[9], 90% of the 300 experts interviewed from US, German and Japanese companies believe that Industry 4.0 will improve their competitiveness and operational effectiveness.

However, the survey confirms that this transformation process is still in its early stages: only 30 percent of technology suppliers and 16 percent of manufacturers have an overall Industry 4.0 strategy in place, and only 24 percent have assigned clear responsibilities for Industry 4.0 in the last year (2015). About half of the US and German players (50 and 56 percent) report having made at least good/substantial progress last year in implementing Industry 4.0 applications, while only a small fraction of Japanese players (16 percent) report this level of progress.

Expectations are of rapid growth: another study by PwC[10] based on a survey of 235 German companies in 2015 reported that today, only one fifth of the industrial companies have digitized their key processes along the value chain; in five years' time, 85% of companies will have implemented Industry 4.0 solutions in all important business divisions.

From a different perspective, IDC forecasts confirm a trend of fast growth of technology investments in manufacturing. In the new Worldwide Commercial Robotics Spending Guide[11], IDC forecasts the EMEA (Europe, the Middle East, and Africa) spending on robotics and related services to grow at a compound annual growth rate (CAGR) of 13% from nearly $14.6 billion in 2015 to $23.8 billion in 2019. Manufacturing (share of 65.7% in 2015) and resource industries (share of 8.7% in 2015) are, and will remain, the two biggest verticals for robotics spending over the forecast period.

The main application areas in which Industry 4.0 investments were concentrated in the last year, according to the Mc Kinsey survey, include smart energy consumption, real-time supply chain optimization, remote monitoring and control, digital quality management, and digital performance management, all areas where exploitation of data and data sharing play an important role. Moreover, among the main implementation barriers the interviewees quoted concerns about cybersecurity and data ownership when working with third-party providers, again issues which can be dealt with through industrial data platforms.

Given the early stage of development of industrial data platforms, it is difficult to find evidence about their specific business and economic impacts. However, there is a broad consensus among analysts

[9] http://www.mckinsey.com/business-functions/operations/our-insights/industry-40-looking-beyond-the-initial-hype

[10] PwC, Opportunities and challenges of the industrial internet, 2015 http://www.strategyand.pwc.com/reports/industry-4-0

[11] http://www.idc.com/getdoc.jsp?containerId=prUS41067416

that digitization of industrial processes, facilitated by data platforms, will bring about relevant productivity and efficiency improvements. For example, IDC Manufacturing Insights[12] foresees that by 2019, 75% of manufacturing value chains will undergo an operating model transformation with digitally connected processes that will improve responsiveness and productivity by 15% on average.

The PwC study confirms this, with the companies surveyed anticipating an average efficiency increase of 3.3% per year across all industry sectors due to the digitization of value chains. This amounts to a total of 18% in the next five years. They expect annual savings of 2.6% with respect to cost reduction.

The Boston Consulting Group (BCG) in a study on the future of the manufacturing industry in Germany[13] estimates that productivity improvements on conversion costs, which exclude the cost of materials, could range from 15 to 25 percent thanks to Industry 4.0 during the next 5-10 years. These improvements will vary by industry. Industrial-component manufacturers stand to achieve some of the biggest productivity improvements (20 to 30 percent), for example, and automotive companies can expect increases of 10 to 20 percent.

Both BCG and PwC agree that companies will also collect additional revenues thanks to the digitization and interconnection of products and services (based on internet of things/services). According to the PwC survey, companies expect to gain additional revenues of 2% to 3% per year on average. When applied to the German industrial landscape as a whole, additional revenues could reach up to €30 billion per year. For the European industry sector, additional revenues could amount to €110 billion annually. BCG foresees as well a potential 6 percent increase in employment during the next ten years, accompanied by a change in the demand moving away from low-level skills towards advanced skills. However, this digital transformation of production process will require sizable investments, estimated by BCG at about €250 billion during the next ten years (about 1 to 1.5 percent of manufacturers' revenues).

[12] http://www.idc.com/getdoc.jsp?containerId=259783

[13] https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/

3 Industry Data Platforms at Work: Select Case Studies

3.1 Investigating Industry Data Platforms in Europe

An initial attempt to draw a non-exhaustive landscape of industrial data platform initiatives in Europe and elsewhere has been presented in chapter 2 of this document. In the following paragraphs, we will profile in detail three industrial data platforms based on their relevance, stage of development and primary research efforts.

3.1.1 Case Study 1: COMBIENT

Background Information

Combient is a Joint Venture that brings together eleven different organizations headquartered in Sweden representing a wide array of sectors and specializations – from industrial tools and equipment manufacturers to home appliance and aerospace & automotive organizations; from pulp & paper to mechanical engineering and mining companies; from networking and telecommunication equipment manufactures to IT consulting & management, corporate banking and finance services providers.

Founded in January 2015, Combient is incorporated as a public limited company with its head office in Jaerfaella (Stockholm). It currently includes Atlas Copco AB, Electrolux AB, Ericsson AB, FAM AB, Investor AB, LKAB, Saab AB, SEB AB, Sigma AB, SKF AB and Stora Enso AB, thus representing an owner group of some 330,000 employees and a total turnover of about 665 Billion SEK (approximately 69 Billion EUR). While presently limited to Swedish organizations, the joint venture is open to companies and organizations outside the country and the Nordic area and is actively involved in other industry partnerships and consortia outside Sweden and indeed outside Europe (please see: "Current Situation and Future Perspectives" below).

Combient's principal objective is to bring digital innovation to the industry, with particular attention to those companies and organizations that are not "digitally native" and that may encounter more difficulties in their journey towards the computerization of manufacturing and industrial Internet as a whole.

Key Activities, Specialization and Needs Met

In pursuing its mission, Combient leverages two main axes: automation and collaboration.

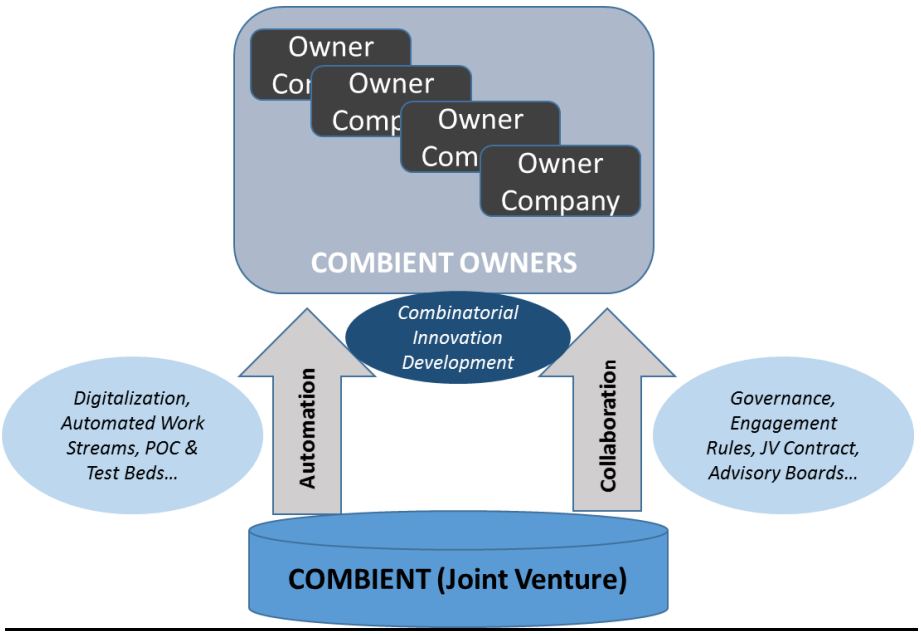
• Automation is enabled by a common automation development environment serving the Joint Venture with all the necessary technologies supporting the creation of Test Beds and Proof-of-Concepts that demonstrate the viability of software-based Automation Systems within and between the owner group of companies.

• Collaboration is achieved through constant engagement and interaction with the owner companies within the Joint Venture and with exchanges with select industry & technology partners, as well as with research and academia, outside the Joint Venture. For example, Combient has interaction with "Industrie 4.0" – Germany's flagship initiative to promote computerization of manufacturing – and is an active member of the "Industrial Internet Consortium (ICC)"– the U.S.-led not-for-profit consortium that is setting the architectural framework and direction for the promotion of the Industrial Internet. In the research and academia space, Combient works closely with some of Sweden's most prominent institutions including Linkoepping University, KTH-The Royal Institute of Technology, Luleå University of Technology (LTU), Umeå University, SICS Swedish ICT, and Stockholm University.

Together, automation and collaboration allow Combient to develop and deliver a wide range of innovative solutions for the industrial sector ("Combinatorial Innovation & Development" in Combient's jargon). This innovative potential is translated into tangible benefits for the owner companies and for the industry and technology partners outside the Joint Venture leading to improved execution capacity, better access to competence and skills and reduced time to market, just to mention a few.

Combient's operations setting is outlined in Fig. 1 below.

Figure 1: Combient's Operations Setting



A decentralized and distributed approach underpins Combient's governance model and its internal engagement rules. This is made possible by the non-competitive nature that characterizes the relationship among the owner companies and by the dominating egalitarian culture sustaining the Joint Venture. The governance model for the Joint Venture lays down a set of rules regulating the relationship among the owner companies. In addition, two advisory groups (one focusing on operations and one on technologies) meet twice a year to supervise the interactions among the Joint Venture's participants and act as conflict-solver.

Current Situation and Future Perspectives

The concept of industry data platforms bringing together different organizations from a variety of multiple sectors and with the aim of fostering digital innovation in several industries (including the most traditional, non-digital-native ones) is in its initial phase. Yet, the creation of such ecosystems features already some prominent examples in Europe (Combient being the most notable initiative in the Nordics but other initiatives are present in Germany and Spain) and in the U.S. (e.g.: The Industrial Internet Consortium) and the trend is clearly set for the years to come.

To capitalize on this positive momentum, Combient is engaged and involved in several industry partnerships and consortia (Germany's Industrie 4.0 and the US Industrial Internet Consortium are two prominent examples) and is actively looking for new forums, member- and partnerships that will further enable and support its vision. In particular, the joint venture is planning to extend and strengthen its collaboration model. To this aim, Combient recently launched the "Associated Member Programme" - a

by invitation membership program into which it will look to bring in additional enterprises from various industries - with the objective that each new member will add value to the already existing collaboration model and community. Three new Associated Members joined the joint venture as of July 1st 2016: Husqvarna, Södra and Wärtsilä.

3.1.2 Case Study 2: Fraunhofer's Industrial Data Space

Background Information

At the end of 2014, some of Germany's most prominent actors in the business, research and public sector launched "The Industrial Data Space" initiative with the aim of designing, developing and putting to use a shared data platform at European and worldwide level. Two underlying trends were at the core of this initiative:

- The thriving process of digitalization, which is now extending its reach well beyond the technology per se to become a fundamental driving force for businesses and the society as whole;
- The changing role of data that, from a mere element of support for business functions, has turned into a new interface between providers and customers thus becoming, in the process, a product itself. As such, data are exchanged, used, and re-used to extend and enrich the world of digital products and services, so to reinforce the overall process of digitalization.

In order to bring forward both the theoretical framework and the practical use of the platform, the initiative was organized around two main branches: a research project and a non-for-profit user association.

- Endowed with an initial amount of approximately 4 million euros funded by the German Federal Ministry of Education and Research (BMBF), the Industrial Data Space research project focuses on the establishment of a pre-competitive data platform with the aim of developing and testing a reference architecture model for the actual data space. As such, the research project is primarily of scientific and technological nature and sees the participation of twelve Fraunhofer Institutes across Germany[14] ;
- The Industrial Data Space user association ("Industrial Data Space e.V.), on the other hand, was founded in the beginning of the year 2016 including among its members some of the most significant representative of Germany's and Europe's manufacturing, IT, and services industries[15]. Its aim is to identify, analyze and evaluate the requirements of user companies so to design a data space that really meets the need of the industry. Moreover, the user associations leverages on the work of the research project by contributing to the development of the data space architecture and by promoting its standardization.

[14] *Fraunhofer-Institut für Angewandte und Integrierte Sicherheit AISEC, Garching bei München, Fraunhofer-Institut für Angewandte Informationstechnik FIT, Sankt Augustin, Fraunhofer-Institut für Kommunikation, Informationsverarbeitung und Ergonomie FKIE, Wachtberg-Werthhoven, Fraunhofer-Institut für Offene Kommunikationssysteme FOKUS, Berlin, Fraunhofer-Institut für Intelligente Analyse- und Informationssysteme IAIS, Sankt Augustin, Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO, Stuttgart, Fraunhofer-Institut für Experimentelles Software Engineering IESE, Kaiserslaute, Fraunhofer-Institut für Materialfluss und Logistik IML, Dortmund, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung IOSB, KarlsruFraunhofer-Institut für Produktionstechnik und Automatisierung IPA, Stuttgart, Fraunhofer-Institut für Software- und Systemtechnik ISST, Dortmund, Fraunhofer-Institut für Sichere Informationstechnologie SIT, Darmstadt*

[15] *Allianz SE, Atos IT Solutions and Services GmbH, Bayer HealthCare AG, Boehringer Ingelheim Pharma GmbH & Co.KG, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V., KOMSA Kommunikation Sachsen AG, LANCOM Systems GmbH, PricewaterhouseCoopers AG, REWE Systems GmbH, Robert Bosch GmbH, Salzgitter AG, Schaeffler AG, Setlog GmbH, SICK AG, thyssenkrupp AG, TÜV Nord AG, Volkswagen AG, ZVEI - Zentralverband Elektrotechnik- und Elektronikindustrie e.V.*

Key Activities, Specialization and Needs Met

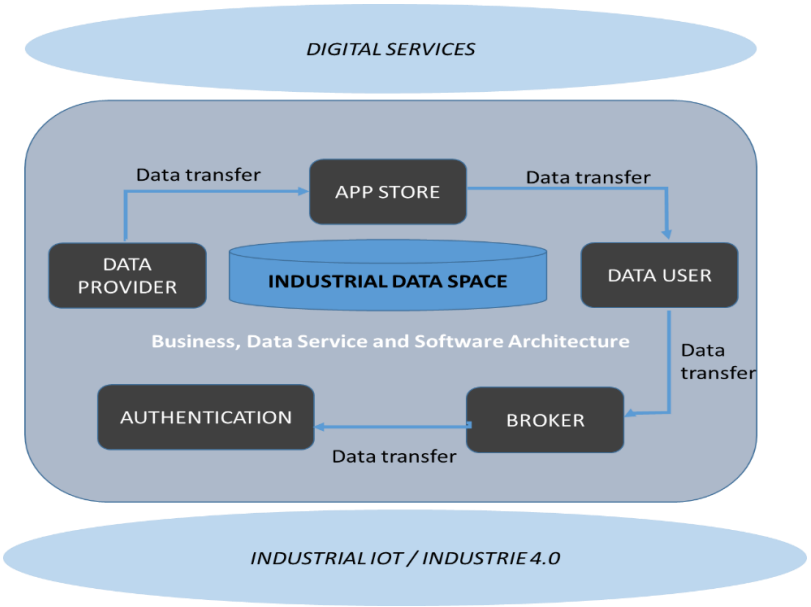
The Industrial Data Space operates as an interface between the Industrial IoT/Industry 4.0 and the world of digital services enabled by data-driven technologies. In practical terms, it is conceived and organized as a network of platforms and services including:

- **Data providers**, i.e. individual companies, "things" (cars, machines, sensor-endowed equipment), other platforms and data market places generating and putting data at the disposal of other entities;
- **Data users**, i.e. other data space's participants receiving and using the data generated by data providers to create innovative data-based services;
- **Data brokers**, acting as physical and virtual mediators between data providers and data users and supervising the data exchange (i.e: recording the data transaction, publishing the data sources, helping to find an agreement between the parties exchanging data as of the terms and conditions of the data transaction, if necessary);
- **App store operators,** providing and making available the necessary software for other participants to develop digital-based applications;
- **Certification authority** making sure that the application developed by the space's participants is conformant to the requirements established by the Industrial Data Space itself and by accredited rules and standards.

To work properly and efficiently, the Industrial Data Space is endowed with a business architecture presiding over the rights and duties of the different parties within the data space, the actual data management process and the compensation for data use and access to additional services (business model). This architecture is accompanied by a data and service architecture specifying in details the respective functions of the app store operators and the data broker. Finally, the architecture is also equipped with a connector, which performs the actual data exchange and data processing functions.

A simplified view of the Industrial Data Space's functioning is presented in figure 2 below.

Figure 2 Industrial Data Space – Functioning and Operations



Current Situation and Future Perspectives

The research project of the Industrial Space has a duration of 36 months and is now in its first year of existence; the Industrial Data Space e.V. (user association) was founded in January 2016 and is currently increasing the number of collaborating user companies. Both are therefore at a very early stage and are starting producing results now.

The user association in particular has initiated a series of application cases where the secure exchange and linkage of data is being tested and implemented in practice. These cases have all in common the ability of linking data from several sources, integrate data of different classes (master data, production data, business data…) and diverse categories (private data, public data…), merge and different enterprise architecture compatible and, finally, provide data-driven "smart services". As an example, the user association has recently launched a proof of concept project on truck and cargo management in inbound logistics where the Industrial Data Space will allow for the standardization and simplification of the data exchange between customers, suppliers, carriers and other logistic services providers along the whole logistic supply chain so that all the activities to be conducted upon the arrival of a truck (check-in, assignment of docks and personnel for cargo discharge, job order planning in production, etc..) can be completed smoothly, on time and faultlessly by all actors involved. Other similar application cases are being implemented in the development of medical and pharmaceutical products, in collaborative production facility management and in end-to-end monitoring of goods during transportation.

Going forward, both the Industrial Data Space research project and the Industrial Data Space user association will intensify their efforts to:

- Increase the funding and resources at their disposal and enlarge the number of participants. In this respect, a closer collaboration with other initiatives at European level would be beneficial as the two initiatives are now steered by and depend primarily from German financial resources. A better integration with the BDVA and other H2020 and cPPPs-led initiatives could certainly represent a boost in the future activities of the Industrial Data Space.
- Extend their reach at international level seeking cooperation not only with European players but also with global actors so that the Industrial Data Space's architecture can be fruitfully integrated with other platforms in and outside Germany.
- Expand the number of application cases as well as the overall application scenarios to leverage the highest possible economies of scales and profit from enhanced networking effects.
- Multiply its efforts in communication, information and training to make sure that broad dissemination of the reference architecture model of the Industrial Data space is fully understood and endorsed across the widest possible number of potential users and participants.

3.1.3 Case Study 3: MINDSPHERE – SIEMENS CLOUD FOR INDUSTRY and SAP HANA CLOUD PLATFORM

Background Information

Over the past two years, Siemens has been working on a proprietary industrial cloud platform to adjust its offering to the increasing process of digitalization in the manufacturing industry and accommodate the next business model based on data-driven, smart services. At the beginning of 2016 the beta version of Siemens "MindSphere" was finalized and its subsequent commercial version was launched on the market shortly after.

MindSphere's cloud system is open to industry manufacturers that can use the platform as the basis for their own digital services, with particular reference to the fields of preventive maintenance, energy data management and resource optimization. Unlike other industry platforms, MindSphere is therefore conceived for industry manufacturers and industrial companies, with the aim to provide them a "turnkey", easy-to-access, and ready-to-use solution to connect their machineries and equipment, retrieve and

exchange data and eventually optimize the performance of this equipment and build new services on top of them thanks to the application layer provided by Siemens and integrated to the platform.

MindSphere is based on SAP HANA Cloud. The company preferred HANA Cloud to utilize the power of In-Memory computing and the open standards maintained by SAP HANA Cloud platform. With this, real time data analysis and processing of big data would be possible, which will ignite the efficiency in process chain of manufacturing industries.

Key Activities, Specialization and Needs Met

The data which is fed from sensors and received into the cloud could be processed in real time by SAP HANA, this can transform the big data into smart data which will provide smart insight of information, thus real time decision could be taken effectively. The cloud for industry is bundled with a wide range of services to optimize processes in manufacturing industry.

MindSphere interlinks the physical production system with digital form and helps to optimize asset performance, energy consumption, time required for production, maintenance and services. In fact, Siemens Cloud for industry allows the large volumes of data generated during the production process to be collected, saved, and analyzed in real time and turned into information. This in turn allows for a whole new dimension of services that contribute to improved asset management and energy efficiency through data analysis and simulation. As an example, a process in chemical industry could transmit data for analysis into the cloud and after analysis if it is found that in a particular temperature the process would act more efficiently, then in real time it would be possible to change the parameters of that process in the physical system in more effective way. The platform therefore makes it possible for a company to access its assets in real time, remotely, perform continuous monitoring and on-line data analysis.

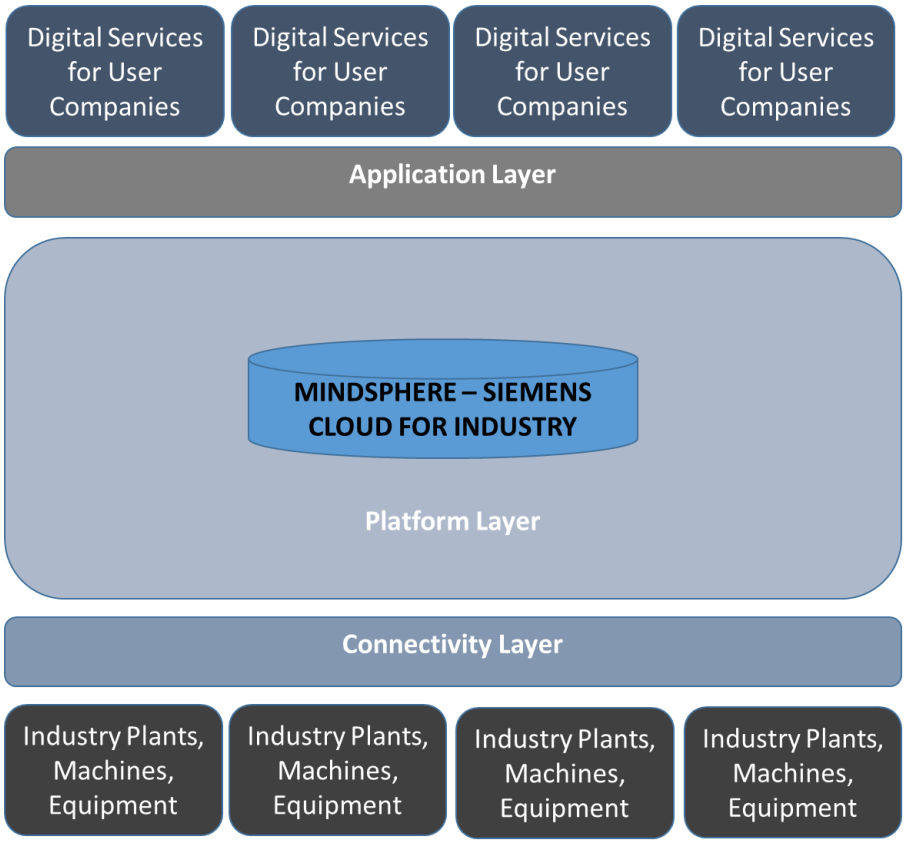
The actual connection of one company's assets (machines, engines, turbines, other manufacturing equipment) to the platform is made possible by a connector, which has been developed further by Siemens during the pilot phase and is now offered under the name of "MindConnect Nano". The connector makes it possible to easily and securely collect machine and plant data – such as data from PLCs or drive systems from Siemens and other manufacturers – and transmit them to the cloud. The cloud platform can be used by all customers, and devices by third-party manufacturers can be integrated into the system The company is currently working on other options for connecting machines and plants to MindSphere, including a Software Development Kit and a software agent.

MindSphere operational setting is built on three fundamental layers:

- A connectivity level allowing the linking and data transfer of data form the manufacturing plants and machines to the cloud platform through a series of sensors;
- The actual cloud data platform itself where data can be safely maintained and stored;
- The application level where data analysis on machine performance can be operated by Siemens and by other companies and on which additional application-based services can be built.

MindSphere overall operational setting is outlined in Figure 3 below.

Figure 3 MindSphere Siemens Cloud for Industry – Three Layers of Activities



Current Situation and Future Perspectives

Like other initiatives of this kind, Siemens Cloud for Industry-MindShpere is still in its initial phase but is already attracting a lot of attention from the manufacturing industry at global level. Siemens however is aware of the need to collaborate with other initiatives, especially at the European level and, in this respect, is seeing very favourably the European Commission's efforts related to the establishment of a Digital Data Market in Europe. in particular, as a truly European (and indeed global) multi-corporate group, Siemens harbours high expectations int the Free Flow of Data initiative and its objective to reduce the restrictions on the free movement of data within the EU and improve the conditions of data exchange across Member States by lowering the hurdles related to the location of data for storage processing purposes

Siemens' MindSphere is an ongoing but very young venture as it was launched in the first half of 2016. It is therefore premature to judge its functioning in the light of the existing data-related policy initiatives at national and European level. Nevertheless, it is fair to assume that other measures beside and beyond the Free Flow of Data initiatives would be extremely beneficial for the success of Simens' and Siemens-like cloud platforms. Among them are the rules concerning data privacy and security. The new General Data Protection Regulation has certainly introduced a considerable element of clarity and reduced ambiguity around this topic but further intervention would be needed to ensure that data transfers between companies based in different Member States fully benefit from digital services. In this respect, other initiatives at the EU level aimed at supporting digital transformation across the European industry are welcome. The current EC initiatives around the digitizing of the European industry and, in particular, aiming at boosting digital innovation through the creation of digital innovation hubs across the Continent are going in the right direction as they allow companies like Siemens to benefit from a wider network of testing environments, while improving the overall digital skills in the industry, especially across SMEs.

Finally, further cooperation with international standardization bodies and the support to initiatives such as the Fraunhofer's Industrial Data Space in the field of standards are deemed necessary to give critical mass to the European industry and increase their weight on the international scene.

4 Final Considerations and Conclusions

4.1 General Overview and Impact of Industrial Data Platforms

While still in its infancy and, in many respect, at a piloting stage, industrial data platforms are rapidly gaining momentum in Europe and in the rest of the industrialized world. In establishing a trusted network for data access, transfer and usage, they are opening up new business ecosystems and rapidly disrupting traditional value- and supply-chains in bringing together a wide array of disparate players from a multitude of sectors. As such, they represent one of the key enablers of digital transformation an essential element for the ongoing industry digitization.

Yet, industrial data platforms are not easy to define, at least at this initial stage. Beyond the general definition of virtual environments facilitating the exchange and connection of data, their actual implementation displays a diverse picture where two opposite models coexist. On the one hand, industrial data platforms may take the form of open, multi-company-led environments that are conceived to meet the requirements of a wide community of industry users from different industry sectors; on the other hand, single-company initiatives are emerging where an individual organization (usually a prominent ICT player or a leading industry actor) establishes its own data platform and open it to other companies for commercial purposes and primarily within the boundaries of a specific industry sector. In either case, industry data platforms are not only allowing data to be accessed, exchanged and used in a secure and trusted environment but they are also unleashing benefits that go beyond the mere technical and architectural aspects. Through the use of "connectors" and "application layers", they are also providing their participant companies with the possibility to develop customized applications and, as a result, an ever growing number of company-tailored digital services. This, in turn, generates economies of scale and networking effects that will be critical for the success of the overall industry digitization, whether at national, European or world level.

Companies are already starting to realize the advantages of this new model of exchanging data in terms of both productivity and efficiency improvements. IDC Manufacturing Insights, for example, foresees that by 2019, 75% of manufacturing value chains in EMEA will undergo an operating model transformation with digitally connected processes that will improve responsiveness and productivity by 15% on average. Again both the Boston Consulting Group and PwC believe that digitization and interconnection of products and services will also allow companies to again additional revenues of 2% to 3% per year on average. If confirmed, these gains could amount to approximately €30 billion per year for Germany's industry alone and to €130 billion per year for the European industry as a whole.

4.2 Initial Policy Considerations

If digital transformation and the digitization of the industry appears today as an unrelenting process, policy makers at national and European level should devote their efforts to help the European industry and, in particular, its core layer of SMEs, grasping the full benefits of this phenomenon. Our secondary research as well as the case-studies featured in this paper have highlighted how a growing number of industry players is willing to converge towards industry data platforms to respond to a series of different challenges. Some players focus on the ecosystem and on the benefits that joining a data platform would release in extending their value chains and expanding the traditional vertical sectors. This is the case of data platforms that can form around multi-sided business and operational models such as connected cars, smartgrids and smarthomes. Other industry actors tend to prioritise on cybersecurity and trust and see the nascent data platforms as a way to develop safer environments equipped with the most accepted and up-to-date standards (this may be the case of players in the financial sector or in specific

industry niches such as defence and arms industry, for example). Other players again privilege the technology requirements and the possibility to use data platforms to access cutting-edge ICT solutions and build their own digital services.

The case-studies presented in this report feature different forms of data platforms – from Siemens' MindShpere that represents the typical case of single-company, proprietary platform to Fraunhofer's Industrial Data Space embodying the characteristic example of an open platform; and with Combient positioning itself somewhere in the middle of this continuum. The rapid digitization process, and the ever increasing amount of data generated in the industry and elsewhere, seems however to push industry companies towards platforms' models that that allow to retain a certain degree of control and flexibility on their actual business and technical requirements. This is giving the open, multi-company-led model of data platforms some sort of lead vis-à-vis the competing model of proprietary data platforms.

European policy-makers should therefore focus their attention on measures accompanying the creation of data governance models and other framework conditions facilitating the emergence of open data platforms so to allow European companies to avoid the negative externalities of proprietary industrial platforms (lock-in effect, supply-driven approach, lower level of control on proprietary data, centralized data governance and technical architecture). In particular, attracting an ever increasing number of companies and achieving critical mass would be fundamental for open platforms to become recognized and successful and a wide range of industry actors (including third party developers, suppliers and users) should be encouraged to join the platforms and build applications and services that run on them. To this aim, legal aspects related to data transfer and data use, as well as implications emerging from data ownership and control and close cooperation with international standardization bodies, should be duly considered to reduce barriers and risks and encourage more users to embrace the open data platform model. Extending the concept of open data platforms and fostering its implementation across the manufacturing industry and beyond, would therefore give European companies – especially SMEs (the backbone of Europe's industry) – an edge over their global competitors, while helping creating integrated and horizontal ecosystems that would represent fertile ground for innovation.

Indeed, US manufacturing companies are showing growing interest in open data platforms and are seeking to break into closed-loop solutions via the channel of standardization, in much the same way as the Internet Protocol swept away everything in its path in the 1990s. The launch of the Industrial Internet Consortium (IIC) in early 2014 is indicative of these efforts. Likewise , some of the leading actors of the proprietary platform model are starting to recognize the value of open data platforms and are joining the movement (this is the case, for example, of Siemens that, while developing its own proprietary cloud-based platform, is also collaborating with the Fraunhofer's Industrial Data Platform).