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Business Innovation Observatory

Service Innovation for Smart Industry

Cyber-physical systems in the 'value network'

Case study 37

Internal Market, Industry, Entrepreneurship and SMEs

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Cyber-physical systems in the 'value network'

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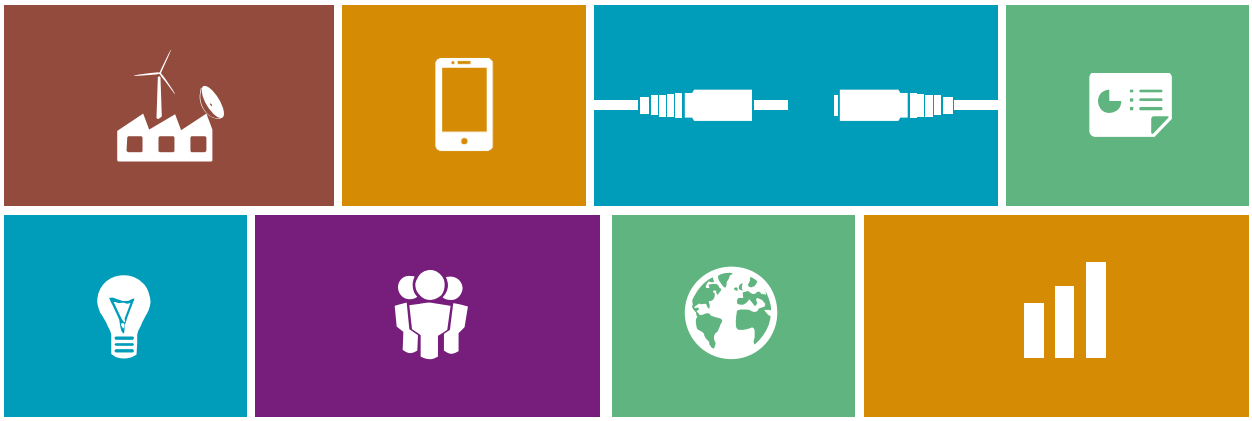


1. Executive summary

Thanks to technologies such as the Internet of Things (IoT), embedded systems, Machine to Machine (M2M) communication, cloud computing we are at the verge of what is considered the **fourth industrial revolution**. In parallel, hyper connectivity will lead to a tectonic shift in the structure of the current economic system: the passage from a linear value chain, to a non-linear **'value network**.'

Cyber-Physical Systems (CPS) are the **enabling technologies** that lie at the heart of this radical transformation to a network-based economy. These CPS allow the creation of integrated and self-regulating systems beyond firm- or industry boundaries, which are instrumental in the optimisation of production processes. The production systems in a CPS-enabled smart factory will be able to react in real-time to changes on the market and in the supply chain adjusting the flow of goods autonomously.

CPS is also enabling companies to offer **remote services** beyond their traditional competencies. These services can take various forms, but are likely to revolve around a few key themes: predictive & prescriptive analytics, remote access, and remote monitoring.

Given the many areas of application, CPS will have a far-reaching impact on the overall competitiveness of industry and manufacturing. The technological complexity of the upcoming smart industry will give its first adopters a significant head-start and competitive edge in the global marketplace. As the enabling technology for smart industry, the market potential for CPS is enormous.

Furthermore, the CPS-enabled world is likely to overhaul today's concept of a value chain. Thanks to the interconnectedness via CPS, a value network is generated: a host of new and existing actors encompassing all stages of production will be able to integrate both vertically and horizontally.

Remote services enabled by CPS are driven by technologies that spur connectivity, high-level political attention to the topic and by emerging market opportunities. Enhanced connectivity through better broadband infrastructure, sensor and computer technology is the pre- condition for the development of CPS. Additionally, policy initiatives such as Industry 4.0 are creating a momentum for CPS and related technologies and are having a positive impact on the companies that operate in remote services for smart industry. The potential for new business models is further spurring interest for CPS: the manufacturing industry understands that it will soon need to reinvent its business and focus on after-sales and services.

On the other hand, concerns about security, technical challenges, and the limited understanding of the market from consumer side still represent barriers to a full uptake of this trend. Security represents the number one preoccupation of consumers when they approach remote services, as this entails placing sensitive information on the cloud. The full implementation of CPS raises a number of technical challenges, such as interoperability and broadband infrastructure.

Policy support to CPS is surely needed in the form of the right framework conditions. This entails establishing provisions for data security and privacy, ensuring interoperability and fostering a company ecosystem as the next generation market place. Also the support to enter a challenging market, in particular for SMEs and start-ups, will be beneficial to the uptake of the trend.

2. CPS services in the Value Network

2.1. Presentation of the trend

Digitalisation and ubiquitous connectivity are already shaping our economy in an unparalleled way. Yet, today's advances in technologies such as the Internet of Things (IoT), embedded systems, M2M communication, cloud computing provide the starting point for what is considered the **fourth industrial revolution**. In parallel, hyper connectivity will lead to a tectonic shift in the structure of the current economic system: the passage from the linear value chain, to a non-linear **'value network**.'

Cyber-Physical Systems (CPS) lie at the heart of this radical transformation to a network-based economy. The term describes the "integration of computation with physical processes" or "the merging of the cyber- and the physical world". Simply put, CPS are the **enabling technologies** that allow the creation of integrated and self-regulating systems beyond firm- or industry boundaries.

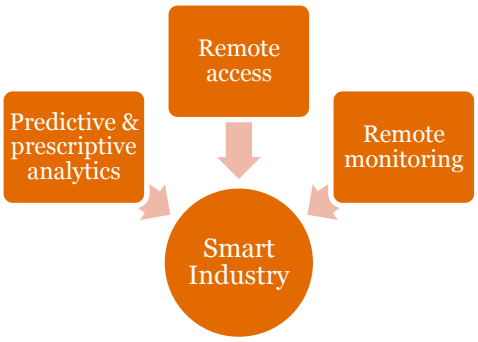
Today the cyber and the physical world have already numerous meeting points: Product Life cycle Management (PLM), cloud computing and big data from the cyber-side; embedded devices, Machine to Machine (M2M), Internet of Things (IoT) from the physical side. In the context of the upcoming smart industry, the cyber system will constantly monitor the physical processes. Both worlds will be connected seamlessly and constantly interact with each other.

Concretely, the production systems in a CPS-enabled smart factory will be able to react in real-time to changes on the market and in the supply chain adjusting the flow of goods autonomously. As a result, the entire production chain will be optimised to an extent that is beyond imagination today.

But CPS go beyond the optimisation of production processes. In fact, CPS is enabling companies to offer **remote services** beyond their traditional competencies. These services can take various forms, but are likely to revolve around a few key themes: predictive & prescriptive analytics, remote access, and remote monitoring.

Predictive and prescriptive analytics make sense of raw data that otherwise would have little value. With techniques such as statistics, modelling, data mining, and machine learning predictive analytics is key to making predictions notably on the maintenance of machines or on resource efficiency. Prescriptive analytics, on the other hand, is about being able to predict possible future scenarios and on that basis recommending a course of action in order to avoid future negative impacts. Such analytics solutions are often software-based but may entail hardware part as well. As the name describes, remote access allows to use and to configure a device from a remote location through a secured communication channel. Remote monitoring, on the other hand, allows monitoring and controlling the equipment as well as accessing its data.

Figure 1: Remote services connected to smart industry



Source: PwC Analysis

The multiple benefits of these developments are evident: the production process is optimised in all its phases; supply chains run smoothly on a 'just-in-time' mode; manufacturers are able to mass-customise products in response to consumer demand; and finally, unexploited business opportunities arise from CPS-based networks.

While much of the discussion around CPS and Industry 4.0 is still at a conceptual stage, some companies are at the forefront of these developments; many others, on the other hand, are watching closely. In order to gather a solid understanding of this trend, this case study will showcase successful examples of remote services revolving around CPS currently available on the market.

Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
Predict	France	Specialised in real/delayed-time Condition Monitoring, Predictive Diagnostic support, Prognostic and Heath Management	- Participant in Factory of the Future PPP as well as in numerous EU-sponsored research projects (FP7, FP6, FP4) - Local TV coverage
eWON	Belgium	Talk2M: cloud connectivity solution for industrial machines	- Mesures Magazine in France awarded the eWON Flexy as an innovative product in the field of industrial communication - The M2M Evolution Magazine in the USA gave eWON Flexy the title of "M2M Product of the Year 2014" - Talk2M was awarded "Product of the Year" in 2013 - Among 25 Belgian companies, eWON received the "Innovation Trophy" award created by the Group Schumpeter. - "Wallonia Export Award 2010" - eWon was awarded the Walloon Region Innovation Prize 2009 for Talk2M - eWON won the 2003 Innovation award at the Automation Fair in Paris
Maintenel Automation	Latvia	Cloud-based hard- and software solution for predictive maintenance	- Financed by JEREMIE – European Investment Bank
IS Predict	Germany	Software solution for prescriptive maintenance	- IS Predict is a member of Scheer Group, the innovation network of Prof. August-Wilhelm Scheer - Nominated for Big Award of Medium Enterprise by Oskar-Patzelt-Stiftung - Awarded for extraordinary innovations by GFFT e.V. (non-profit company to support research transfer) - Visit by the Saarland Minister for Economy, Labor, Energy and Traffic Anke Rehlinger - Visit by MEP Jo Leinen - Visit by SAP CEO Jim Hagemann Snabe
HMS Networks AB	Sweden	Netbiter: Cloud-based remote access and monitoring service package	- HMS Networks has been named "Swedish Export company of the year" - AAA credit rating from Dun & Bradstreet

2.2. Remote services via CPS

Problem 1 – Machine dysfunction or breakdown can cause large-scale damages to industrial and utilities companies.

Innovative solution 1 – Predict is specialised in real/delayed-time remote monitoring and diagnostics of industrial equipment aimed at anticipating and preventing machine failures.

Predict's flagship products are the e-Maintenance platform named KASEM (Knowledge and Advanced Services for E-Maintenance) and the company's core business technology CASIP (Computer-Aided Safety and Industrial Productivity). CASIP analyses the most significant failures and degradations that may have an impact on the availability of machines, performances and costs. It has a predictive horizon to up to 6 months.

Through *Predict's* two software installation, the performance of machines is constantly monitored and analysed, ultimately allowing generating important savings.

Predict e-maintenance of infrastructure

Source: Predict

Problem 2 – Service trips of machines during warranty period are very expensive.

Innovative solution 2 – eWON provides a cloud connectivity solution for industrial machines that is easy to implement and to use. Customers can access the machine remotely in order to perform the necessary tasks. With *eWON*'s solution industrial machines are connected securely to the Internet, which can gather all types of technical data originating from them.

Typical applications within the scope of *eWON*'s work include remote maintenance, predictive maintenance, remote services, asset management, remote metering, multi-site building management, and M2M.

Connected machine

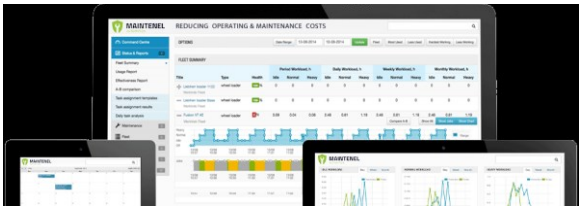
Source: eWON

Problem 3 – Operating and maintenance costs for fleets, factory, processing, and other equipment are very high.

Innovative solution 3 – Maintenel (stands for maintenance electronics) is a Latvian start-up in predictive maintenance. The solution allows significantly reducing the costs of operation and maintenance of heavy equipment and power units in a variety of industrial sectors: fleet management, factory (manufacturing) automation, industrial processing, and other markets. The solution for predictive maintenance is based on rapid-deployment hardware, software and cloud components.

Maintenel devices measure the workload of heavy equipment by counting the periods of time spent in different operation modes. On receiving this data, *Maintenel* Cloud allows detailed labour analysis and enforces timely preventive maintenance (PM) using predictive maintenance (PdM) features.

Maintenel's portal



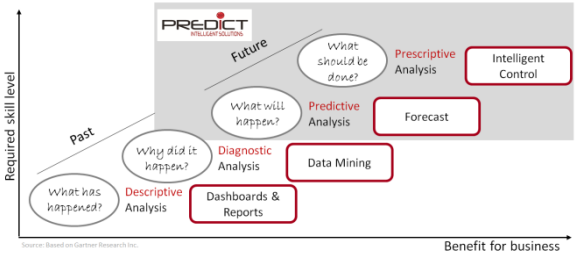
Source: Maintenel

Problem 4 – Data are left unused by companies, but actually contain a lot of value.

Innovative solution 4 – IS Predict is a German software provider in predictive & prescriptive analytics. It has developed a self-learning predictive analytics solution called „Resource Intelligence", which discovers inefficiencies and weaknesses in individual processes of its clients.

The company operates mainly in two fields, namely utilities ('smart grid') and industry production ('smart industry'). Its software solution for smart production increases the efficiency of production processes thanks to data analysis and predictive analytics. The software is capable of understanding inefficiency and providing recommendations for controlling the machinery in an optimised way. Further, complex processes are managed more easily and users are able to take action in advance.

Stages in analytics



Source: IS Predict

Problem 5 – Field equipment needs to be serviced, which involves considerable travel costs.

Netbiter offers a cloud-based remote access and monitoring solution. They provide a service package for monitoring and controlling field equipment, such as power generators, pumps, tanks, wind turbines etc.

As site visits are costly, *Netbiter*'s custom-made remote monitoring systems enables its customers to optimise the service costs by only sending service teams to equipment that actually need service. *Netbiter* offers three types of service packages to its customers: remote access, 'view and control' and 'manage and analyse'. The remote management solution can be deployed within days.

Netbiter gateway

Source: Netbiter

3. Socio-Economic Relevance

3.1. The market potential of the trend

As the enabling technology for smart industry, the market potential for CPS is enormous. However, full-blown CPS as envisioned by Industry 4.0 and similar concepts are still relatively far from being a reality.

This section will focus on the existing markets for remote services, in which the interviewed companies operate, i.e. predictive maintenance, prescriptive analytics, remote access and remote monitoring. These services overall concern early adopters but have not yet reached an early majority. As a result the markets are still largely unexploited.

Predictive maintenance *per se* is not an entirely new development. For instance, *Predict* has been active in the field for more than a decade. Yet, the advances in computing and the ability to store large amount of data on the cloud offer new opportunities to fully develop this service, notably by making the technology more cost- effective. This is reflected in expected growth rates in the range of 6 to 20% according to *Maintenel*. Furthermore, *Gartner* places predictive analytics as a productive technology in the 2013 Hype Cycle for Emerging Technologies.[1]

The market for prescriptive analytics emerged more recently. *Gartner* classifies prescriptive analytics as the fourth stage of analytics capabilities after descriptive, diagnostic, and predictive. *IS Predicts* considers that this type of analytics, too, has superseded the initial hype phase and has the potential to enter the mass market in the near future. However, a potential hurdle to large-scale uptake is the legacy of old machinery in manufacturing, for which no data can be collected.

Similarly to predictive maintenance, industrial connectivity solutions have been available for about a decade already. Again, the cloud is the game-changer in the market. While a niche area before, these services are gaining ground among many industries. *eWON* for instance experienced its breakthrough in 2008 after about a decade of work in the field. The market is still widely unexplored, even though *Netbiter*—who entered later in the game–was expecting higher growth rates.

Remote access solutions are mostly demanded by industrial clients who are interested in the ability to control their equipment from a distance. This allows them to save considerably on travel costs for maintenance trips. Remote monitoring typically adds some functionalities to remote access, such as viewing and downloading trend data as well as monitoring and controlling equipment remotely.

These remote access and monitoring technologies can be horizontally applied to many industry clients, thus making their potential applications wide-spread. They are particularly attractive for machine builders as well as utility and telecom companies that have equipment in the field.

3.2. The social impact of CPS

The fourth industrial revolution does not only concern industry, but will impact society at large. While the concrete implications remain of speculative nature at this stage, a few elements emerge clearly.

To say the least, CPS will have a far-reaching impact on the overall competitiveness of industry and manufacturing. The technological complexity of the upcoming smart industry will give its first adopters a significant head-start and competitive edge in the global marketplace. Europe, and most notably Germany, are at the forefront of these developments and thus must likely to reap their benefits at fullest.

Beyond competitiveness of the industrial sector, CPS have many potential applications in a variety of sectors highly relevant to society as a whole. In fact, CPS are very likely to play an essential role in transportation, energy & utilities, as well as health. For instance, CPS can be of great use in managing traffic flows. It is conceivable that self-driving cars will have real-time access to traffic information and react accordingly, as described in the BIO case study on connected cars. Similarly, energy consumption can be optimised enormously thanks to a CPS smart grid. Ultimately, CPS are key to developing telemedicine as well as to enhancing the use of medical data.

While the societal benefits of CPS are manifold, they open up a Pandora's Box of societal issues that will need to be addressed. Privacy, security and ownership of sensitive data are cases in point. Chapter 4.4 will elaborate on these topics in greater detail.

3.3. The impact on the value chain

The CPS-enabled world is likely to overhaul today's concept of a value chain. Thanks to the interconnectedness via CPS, a value network is generated: new and existing actors encompassing all stages of production will be able to integrate both vertically and horizontally. In the future, software providers, service providers, brokers and end-users may collaborate in a flexible manner for the creation of one item. The conventional boundaries between industry and service sectors will fade away.

In a first stage, CPS allow vertical integration within a firm. This means that the IT systems of all company domains from logistics, resource planning & usage to production and sales will communicate seamlessly with each other through a standardised architecture.

The next level concerns the horizontal integration of multiple vertically integrated conglomerates. Processes are now connected beyond the boundaries of one single entity but encompass practically the entire economic system, including different sectors such as energy & utilities, agriculture.[2]

In such a value network the traditional roles and responsibility can mix and shift. The following scenarios are imaginable: customers can act as designers as they will be able to provide the blueprints for their products; machine manufacturers can become service providers as they will sell not only the machine itself but the aftersales and/or the outcome; new service providers will emerge with radical business propositions. In short, both production and services may be impacted by external stakeholders at all stages of a company's value process through remote integration.

The smart industry context will also alter the value creation. In fact, after-sales and services related to the product will become increasingly prominent in value generation. Companies may even choose to opt for outcome-based business models: they no longer sell the mere product, but the utility the customers derives from it. To make this more tangible, a future value proposition could be guaranteeing the running of a machine for a specified time period instead of simply selling it.

Another important aspect when considering the emerging network is its effect on the competitive environment. Indeed, the complexity of the hyper-connected environment is challenging the ability of players to bring all competencies under a single umbrella. Instead a multitude of small and medium-sized actors are likely to have their own market niche. All of this raises a number of issues in terms of competitive strategy. Companies may need to forge alliances and partnerships, which in turn will compete against each other.

In addition to the far-reaching impact CPS will have in future, CPS already make a difference for clients. Predictive maintenance is associated with approximately 30-40% reduction in expenses for maintenance in terms of savings on fuel costs and unnecessary repairs/replacements. If severe downtimes are taken into account, the savings are even more prominent. Remote monitoring, too, allows significant cost reduction in addition to 24/7 control. In this case the primary benefit is derived from a reduction in unnecessary travel costs, as the field equipment can be serviced remotely.

"The trend will change our customers market, which means it will change our business as well" – ***Netbiter***

4. Drivers and obstacles

Remote services enabled by CPS are driven by technologies that spur connectivity, high-level political attention to the topic and by emerging market opportunities. On the other hand, concerns about security, technical challenges, and the limited understanding of the market from consumer side still represent barriers to a full uptake of CPS.

4.1. Connectivity everywhere

Connectivity lies at the very heart of CPS acting at the same time as a driver and indispensable condition. Beyond connectivity, the advent of the fourth industrial revolution rests upon the continuous development of a number of essential information technologies and 'hard' technologies.

Internet connections have been growing exponentially since their inception. Today almost 3 billion people[3] are online in some form or other, but connectivity has not reached its full potential yet, i.e. ubiquitous connectivity for humans and machines.

In fact, for 2014 more data was forecast to be generated by machines than by human beings.[4] In order to accommodate the connection of a gigantic number of potentially connected devices, the Internet Protocol version 6 (IPv6) was launched in 2012 in order to enable the Internet of Things.

Beyond connectivity, some other key technologies form pre-requisites for CPS. Sensor technology, cloud computing, cellular and M2M technologies are all developing at unprecedented speed and becoming more and more affordable.

Decreasing cost of sending data also makes the Internet of Things possible. [5] With all these technological fields developing simultaneously, the ground will be laid for CPS to flourish on a large-scale basis.

4.2. Industry 4.0 as a vision

While technology is often thought to develop in isolation from policy and society, the political dimension should not be underestimated. Surely, policy will by itself be not sufficient for kick-starting a technological revolution, but it can give a significant push.

*"Having a connected machine is a real added value for the future" – **eWON***

Industry 4.0 as a vision is rallying players and creating a momentum for CPS and related technologies. According to the companies interviewed, it is indeed having a positive impact on their markets.

For instance, *IS Predict* noticed a considerable increase in the interest for their products since the launch of the Industry 4.0 policy initiative. Companies that until a few years back viewed data analytics and remote monitoring as far-fetched are now slowly re-considering thanks to the high-level political attention that the topic is receiving. Furthermore, Industry 4.0 is being closely watched by all relevant players beyond Germany, as *eWON* commented.

While Germany is the frontrunner in this domain, others have followed suit. The Netherlands for instance has devised a comprehensive strategy for Smart Industry. The US, too, is active in the field through the Smart Manufacturing Leadership Coalition (SMLC) and GE's 'Industrial Internet'.

*"Discover the gold that is hidden in your data" – **IS Predict***

At EU level significant research activities are going on under the Factory of the Future (FoF) flagship project. However, overall they are considered less visible and more fragmented according to *eWon*.

4.3. Gearing up for future market opportunities

While savings and efficiency gains are the first level benefits for adopters of remote access/monitoring and/or predictive analytics, many of these users are starting to consider the opportunities that a connected device may offer in future.

Machine builders and the manufacturing industry in general are facing heavy competitive pressure in the globalised economy. Moreover, the manufacturing industry has to realise that in a not-so-distant future it will need to reinvent its business and find new sources of revenues. So far revenues have been generated from the selling of hardware, yet disruptive business models are looming on the horizon. With CPS, after-sales and services will take a larger share in value-added. Consequently, machine builders may end up selling capacities of production instead of products.

Connecting the machine to the cloud via remote access or monitoring system is the entry ticket to these future business opportunities. While these are not yet the primary motivation for hooking up machines to the cloud, they do play an important role in the decision-making. Utility providers are starting to think of offering value-added services based on the data they collect, explains *IS Predict.* Similarly, *eWON* holds that their customers are convinced that having a connected machine is a real added value for the future. "Even though they might consider these developments still far away, machine-builders are convinced that they are coming", *eWON* continues.

*"The major disruption will come from services and aftersale" – **Netbiter***

Developments in the consumer markets are in fact paving the way for industrial connectivity. By observing the explosion of the apps market and similar internet-based services, the manufacturing industry can touch with hand what a connected future could look like.

4.4. What about security and privacy?

Concerns about security represent the biggest barrier to the uptake of remote service solutions and are considered top priority for the showcased companies. Security in the context of CPS services actually can take different forms, most notably data security, security of data flows, as well as protection of Intellectual Property Rights (IPR).[6]

Data security refers to guaranteeing that data is protected from unauthorised access. Establishing a secure communication path, encrypting data and secure authentication are means used to make data safe. As *Netbiter* pointed out, putting factory data on the cloud is still very sensitive issue for many manufacturers, despite the fact that much of the financial and banking runs through similar systems. This has the potential to seriously damage firms' operations and their reputation.

Another aspect of security is related to the possibility of data flows interruptions. Such Denial of Service attacks strain the IT infrastructure to the point that services either are shut off completely or severely limited.

In addition to the above-mentioned security aspects comes the question of data privacy and data ownership. In this respect, CPS opens up a series of questions that will need to be addressed through an appropriate legal framework on IPR in cyber-physical context. For the time being, providers such as *eWON* maintain that the data should remain in the hands of the customer. This, however, could change should appropriate business models emerge.

4.5. Interoperability, broadband & reference architecture

Technical challenges of various natures are another obstacle to the full development of CPS. For starters, a comprehensive broadband infrastructure is a key requirement of Industry 4.0.

In addition to extensive and reliable broadband a series of other technical challenges needs to be tackled. A key aspect is the development of a reference architecture that allows the integration of multiple companies and thus the creation of the value network.

To date, no software application can manage the data generated by millions of connected devices. In order to cope with the complexity of CPS it will be necessary to rely on an overarching software infrastructure. Many aspects could be standardised across industries, for e.g. infrastructure, security and privacy, yet other domains will need to be tailored to specific needs.

Interoperability is another potential area that will require collaboration with the automation industry. *eWON* notes that the automation industry has already developed many interoperability standards and thus should be in a good starting position for continuing to work on the basis of interoperable solutions.

Remote service operators are impacted by the technical complexity, too. In fact, they need to gather market knowledge in many different vertical domains in order to offer the appropriate solution to clients.

4.6. Giving meaning to buzzwords: consumer education

Remote services are growing as a result of demand and technological feasibility. Nevertheless, these services are still at an early adopter stage and have not reached the mass market yet. To become mainstream, CPS need to overcome some key acceptance barriers through effective marketing and consumer education.

The main target markets for CPS, i.e. machine builders, utility providers or other remote equipment owners, are relatively conservative in their outlook. Their industries operate on a long-term horizon with huge capital investments in machineries that are planned to last for decades. Two implications arise from this: first, some of these machines are simply too old for them to be connected to the Internet; second, the industry as a whole has generally a slower pace in adopting and adapting to innovation.

Another concern raised by companies offering remote services is that consumers are often confused by the buzzwords floating around, such as IoT, the “cloud”, or M2M. Worse, they do not have a clear understanding of which remote services are actually on the market and may be confused by commercially available service options, such as remote access versus monitoring or predictive maintenance.

All of this indicates that service providers still need to invest in communication and marketing, despite the fact that showcased companies have declared increased interest and knowledge since the political push delivered by Industry 4.0. Another misconception regards the price of solutions. *Predict* has considered such prices as an obstacle. In fact, many potential customers believe that predictive maintenance is expensive, while today solutions are low-cost and offer a quick return on investment. The take-away is that considerable investment in consumer education is still needed.

On the positive side, younger generations are entering the industry’s workforce and are expecting the same level of connectivity at their workplace as they have in their private lives. The influence of the consumer market is considerable in this respect.

Finally, an effective marketing strategy can counter some of the issues outlined. For instance, *Netbiter* has identified the financial decision-makers as their targets, as the benefits in terms of cost effectiveness are clear messages to deliver. Automation engineers, on the other hand, may be sceptical about IT solutions as this is not their domain.

4.7. Convincing pilot customers

As discussed above, market awareness for CPS is relatively present but the trend is not yet fully accepted. In this challenging environment entering the market as a start-up presents an even bigger hurdle. Consumers are showing a degree of conservatism in implementation and employment of any innovations targeting their usual work scenarios, which is exacerbated if a company has no track record to show for itself. These are the conditions that *Maintenel* is facing now and *IS Predict* has had to face until recently. From *IS Predict’s* experience identifying enthusiastic early adopters through conferences and similar networking activities have so far proven the best method to acquire pilot customers.

5. Policy recommendations

Policy support to CPS is needed mostly in the form of the right framework conditions. This entails establishing provisions for data security and privacy, ensuring interoperability and fostering the company ecosystem that is emerging around cyber-physical systems. Demand-side financial support aiming at helping SMEs and start-ups enter a challenging market is another area of potential policy action.

5.1. Towards a cyber-security strategy

The number one challenge in CPS and remote services is security. Security for industrial data is even more critical than in banking, because insurance schemes cannot cover the losses that are generated through hacking or copying patented technology.

As a result, the threshold for acceptance must be reduced to virtually zero. Policymakers and specialists need to conceive an overarching security infrastructure that is up to this task.

Nonetheless, even the safest architecture cannot prevent criminal activity from happening. As *eWON* pointed out, regardless of the prevention efforts, cyber-attacks will happen. The second step for making CPS viable is thus investing in cyber-security not only from prevention, but also from law enforcement and policing point of view.

Only with a strong and coordinated cyber-security policy will Europe be part of industrial Internet. Today's efforts are not sufficiently developed and lack integration among the Member States. The US on the other hand is already more advanced with respect to its cyber-security.

Companies will be largely responsible for prevention of attacks and the development of a secure CPS infrastructure. Indeed, they are making an important effort in terms of investment in security, as it is the main priority for them. But they are limited in their scope of activities. For instance, a private company will not be able to carry out a crime-related investigation with the same means as a government.

"Whatever the prevention, there will always be an attack"
– eWON

Thus, a significant part of responsibility for cyber-security needs to come from government, as preventing and prosecuting attacks on the web are about protecting public goods. In the EU, a common powerful cybersecurity strategy would be instrumental in that respect.

5.2. Getting the framework right

As with any business activity, setting the appropriate framework conditions represent the basis for its flourishing. This is particularly important when speaking of complex and all-encompassing systems such as CPS and the virtual network.

Policy plays a vital role in setting the rules of the game. Remote services based on CPS require policy action in three main areas: first, interoperability and standards setting in order to ensure seamless communication between all players; second, competition policy needs to guarantee an equal level playing field; third, the legal environment needs to provide legal certainty to all business actors.

The integration of supply chains beyond company boundaries via CPS requires a high degree of interoperability and standardisation. At EU level, this standard definition could be supported by fostering the dialogue between regulators and industry experts. The aim is to define a blueprint for a reference architecture, which reflects systems engineering, IT and automation technology.

As CPS will involve the creation of platforms and network economy, this will have a considerable impact on competition policy. A network bears the risk of creating a monopoly, thus regulation needs to make sure that all players have equal access to it.

The legal environment has considerable impact on business activity. With respect to data flows in CPS many issues are opening up that will require an institutional response. Importantly, the flood of data poses a number of challenges: who owns the data? Who is permitted to collect this data and under which conditions? Who has access right to it? How can this data be managed? All these questions need a political answer in the first place, and second need to be enshrined in the legal framework.[7]

"Those who possess the data will be the winners"
– IS Predict

So far, initiatives have spurred mostly at national level in order to tackle these broad framework conditions. However, given the global character of the CPS-based virtual network, there is ample room for coordination at EU level.

5.3. Easing market entry

The field of remote services comprises different level of maturity. Some companies have been in the business for a decade or longer, while others have entered the market more recently since the push of connectivity.

Despite these differences, the interviewed companies faced similar difficulties in approaching clients, as market acceptance still needs to gain ground. Policy can support both enterprises that are new on the market and the established ones.

High-level policy initiatives such as Germany's Industry 4.0 and the Netherlands' Smart Industry are spurring interest from all sides to new developments. Increasingly, conservative industries are confronted with these realities and are more likely to embrace them.

For this purpose, remote service providers welcome opportunities to exchange, present their innovation and meet stakeholders in conferences and workshops. Many of such initiatives do take place, but they are often scattered around and not necessarily sufficiently visible. In this sense, it would prove useful to set up a more institutionalised approach to both showcasing innovative solutions and informing the public of new developments in CPS. Such an initiative could be branded uniformly across Europe.

Start-ups lament the difficulty to find first customers that are willing to test their products. In the case of remote services, this is particularly difficult given the conservative outlook of the manufacturing industry and the security challenges outlined above.

Public support to overcome the 'death valley' can take different shapes. In the context of CPS, a solution could be to set up a platform at EU level that gathers interested stakeholders. The aim would be to target enthusiastic technophiles that are willing to become pilot customers of start-up companies. Member States could support the initiative either by covering part of the costs of the pilot programmes and by funding the platform itself.

5.4. A company ecosystem as a market place

The network character of CPS generates the need for the creation of an appropriate ecosystem. The complexity of the value network makes it very difficult for a single company to be able to offer an all-inclusive hardware, software and service package. Most likely, companies will specialise in either the software or the hardware.

As *eWON* points out, it is not part of the company strategy to branch out into a different area of expertise, but rather form partnerships with complementary service providers. Such partnerships are served best through a living ecosystem of companies.

*"No single company will be able to provide everything. That's why we need an ecosytem" – **eWON***

In such an ecosystem enterprises can take different roles: producers of components for CPS, communication platform providers, providers of support services, or even operator of the CPS market space. This would entail integrating hardware, providing basic services and guaranteeing data and service quality.[8]

While an ecosystem can grow organically simply based on private initiative, it can also need support from policymaking in terms of infrastructure, funding and bringing together relevant stakeholders. Laying the foundations for such an ecosystem already today would allow Europe to have a competitive advantage in the upcoming developments of smart industry.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Predict	Jean-Baptiste Léger	CEO
eWON	Serge Bassem	CEO
Maintenel Automation	Dmitrijs Mikojelovs	CEO
IS Predict	Britta Hilt	Co-Founder & Managing Director
HMS Networks AB	Staffan Dahlström Thomas Carlsson	CEO Copywriter & Project Manager

6.2. Websites

Predict	http://www.predict.fr/
eWON	http://www.ewon.biz/
Maintenel Automation	http://www.maintenel.com/
IS Predict	http://www.ispredict.com/
Netbiter	http://www.netbiter.com/home

6.3. References

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[3] Statista, available at : http://www.statista.com/statistics/273018/number-of-internet-users-worldwide/

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[5] Bosch 2014, Whitepaper, ”Creating connected manufacturing operations in the Internet of Things”

[6] Vbw 2014, “Dienstleistungspotenziale im Rahmen von Industrie 4.0“

[7] acatech 2011, “Cyber-Physical Systems: Driving force in innovation, mobility, health, energy and production”

[8] Sauer, Olaf & Christian Thiel, "Intelligente Vernetzung der Produktion“, BICC-net, available at: http://www.iosb.fraunhofer.de/servlet/is/21752/Intelligente%20Vernetzung%20in%20der%20Produktion.pdf?command=downloadContent&filename=Intelligente%20Vernetzung%20in%20der%20Produktion.pdf