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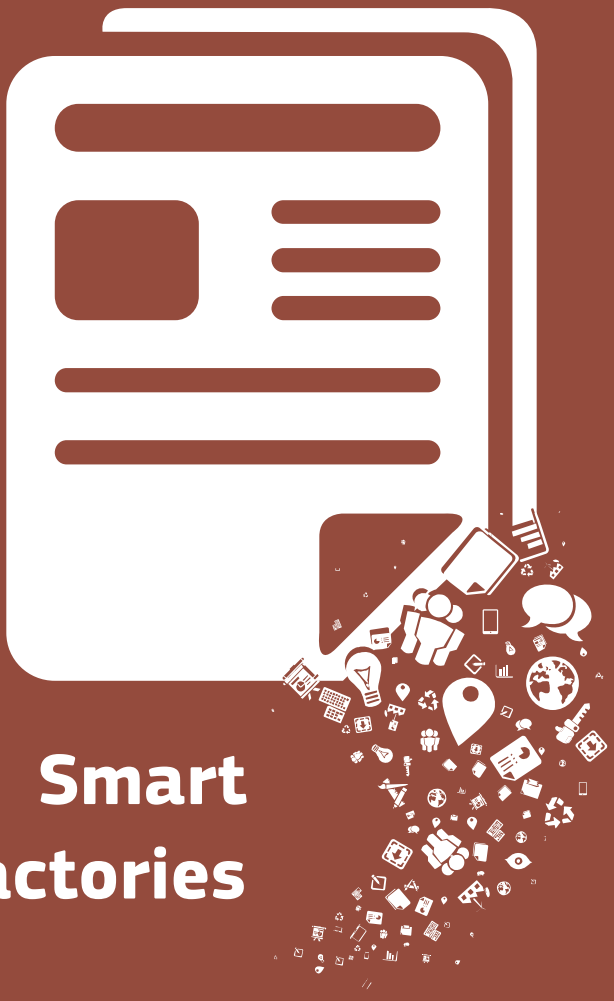

Smart Factories

Capacity optimisation

Case study 26

Enterprise and Industry

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Smart Factories

Capacity optimisation

Business Innovation Observatory
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1. Executive summary

The trend of capacity optimisation is defined as the process by which **manufacturers avoid the sub-optimum use of their resources**. Driven by information and communication technologies, manufacturers increasingly are convinced that networked production devices can not only improve traditional design of production plants, also but unleash a whole new dimension of industrial productivity. Moreover, capacity optimisation provides a **method to make more efficient use of materials and energy**, thus contributing to mitigation of environmental impact of manufacturers; it can also function as a **catalyst to propel the innovativeness, efficiency and optimisation of European factories**.

By 2025, 80% to 100% of manufacturing could be using **Internet of Things applications**[1] meaning that machines, sensors, and other equipment mutually connects and communicates through the internet. This concept of the so-called **Industry 4.0,** combined with capacity optimisation software, is quickly becoming a standard technology in for example designing of factory floors or planning of production routes. No matter for what scale, capacity optimisation software allows manufacturers to make more efficient, speedier, and more controllable production environments where materials, processes, and people can be managed at fingertips.

The companies that were analysed for this case study provide the capacity optimisation tools needed to leverage academic knowledge and expertise in the space of mathematics, computer science, and manufacturing operations to the factory floor. Combined with new technologies and with the Internet, this has sparked a **new wave of innovations that offer manufacturers new possibilities to optimise production**. Whether through cloud technology, augmented reality or a single information technology infrastructure to combine data from various sources, companies that provide capacity optimisation services are successful worldwide in rolling out their services.

However, the process of commercialising capacity-optimisation innovations has not been without struggle. Companies attempting to open-up the market have the potential to rapidly growth, yet also face specific barriers to their success, in particular when moving their technology from the development stage to a successfully marketed product.

The war for talent is a difficult war to win for these smaller and yet unknown companies. Investments in technical studies are recommended as well as **more harmonised labour law across Europe** that makes it easier for smaller enterprises to hire foreign talent across Europe and expanding research and development offices abroad. A common barrier is also the access to finance for small companies. Limited venture capital availability and research project funding as well as a cultural averseness towards an entrepreneurial mind-set can hold companies back from rapid growth.

In their early stages, most capacity optimisation enterprises **depended on a single large client** to propel the business forward and to prove that their technology works. On this aspect, research funding and research programmes provided by universities, by research institutes, and by the European Commission could play a more prominent role.

The adoption of capacity optimisation can be accelerated within the framework of Europe 2020 by providing a common set of labour laws that make it **less unpredictable for entrepreneurs to hire people abroad for their foreign offices**. This initiative could fit within the "flexicurity" programme, although a more tenacious standardisation of labour laws is called for, where the interests of entrepreneurs are in balance with labour protection considerations.

Additionally, project funding through large European tenders is less easy to get access to and less transparent for young companies compared to companies that have more experience with European funding. This may hinder small companies from participating in research tenders. Also, investment in technical education would benefit the uptake of this trend, as innovative capacity optimisation solutions are based on specialised technical disciplines for which talent is highly sought-after.

2. Understanding the trend of capacity optimisation

Capacity optimisation is commonly defined as the process by which **manufacturers avoid the sub-optimum use of their resources**. Manufacturers are becoming increasingly aware of the benefits of capacity optimisation, which is driven by the emergence of new information and communication technologies. Networked production devices – machines which are connected to each other and to the Internet – allow manufacturers to control production processes, know where and when inefficiencies may occur, and design and test a factory floor virtually, without the need to build one. Thusly, capacity optimisation through connected machines leads to reduced waste, increased productivity, and improves traditional methodologies or designing production plants.

Capacity optimisation is often associated with the 'Smart Factory' – a factory of connected and intelligent machines where waste, defect, and downtime are equal to zero. These highly productive factories move materials more efficiently across the factory floor, made possible in part by data seamlessly moving from sensors on machines to servers to services. This is the vision of engineering multinational Siemens which collaborates with Intel and Microsoft to realise the factory of the future where production devices are connected digitally to coordinate and optimise plant resources, employees, customers and suppliers.

*"By 2025, 80 to 100% of manufacturing could be using Internet of Things applications, meaning machines, sensors and other manufacturing devices connected and communicating through the internet" – **Intel***

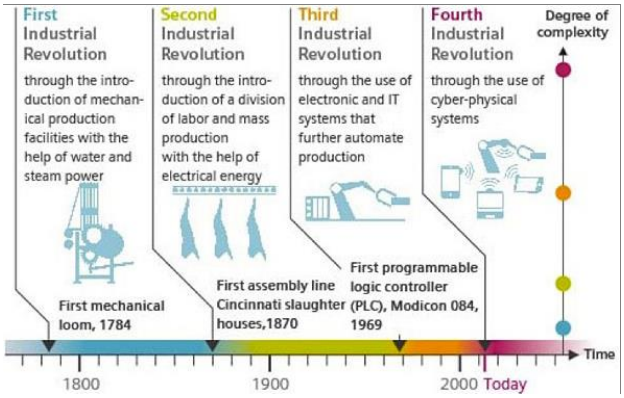
Despite the appeal of the Smart Factory, many manufacturing companies still operate traditional factories that utilise machines in isolation without any interfaces to vertical or horizontal companies with other systems. As a survey from 100 companies in Germany showed, 20% of the companies involved answered that they control and coordinate their production processes and associated production and operating facilities via networked IT systems. In about half of all surveyed companies is the establishment of a Smart Factory 'in planning', while another fifth is considering to address the topic.[2] As a result, companies that have invested in capacity optimisation technology have capability to date to respond more rapidly to changes in demand or supplies or to quality service problems compared to their competitors.[3]

In some large companies, fully networked production has already been established. By 2025, 80% to 100% of manufacturing could be using Internet of Things or IoT applications,[4] The 2014 Digital IQ Survey of PwC showed that 54% of Top Performing businesses are adding sensors to people, places, processes and products to gather and analyse information that allows them to make better decisions and increase transparency.[5] Thus, the Internet of Things can help businesses achieve enhanced process optimisation and increased efficiencies by collecting and reporting on data collected from the production environment.

Capacity optimisation and other innovation trends in the 'Smart Factory' have inspired experts to coin the term Industry 4.0 to describe the increased connectivity of the digital and real world. The term itself has its roots in computer integrated manufacturing (CIM), yet the problem with CIM in the 1970s and 1980s was that the Internet did not yet exist. There were proprietary networks, the so-called fieldbuses that connected machines, but these did not lead to the improvements that warrant the term Industry 4.0. Today, the spread of the internet combined with the decreasing costs of sensors allows CIM to deliver more of its potential benefits to the manufacturing industry, wherein machines, work pieces, systems, and human beings will constantly exchange digital information via the Internet.

Production in the Industry 4.0 era (see Figure 1 on page 4) means interconnected machines for a practically seamless experience: one machine is immediately informed when a part is produced in another machine, as well as a conveyor and a logistic supply robot. Machines automatically adapt to the production steps of each specific part to be manufactured. Even the product may communicate when it is produced through sensor labels or NFC labels – via an Internet of Things application – and ask for a conveyor to be picked up, or notify the ordering system that it is finished and ready to be delivered. Individual manufacturing plants are also interconnected in order to smoothly adjust production schedules among them and optimise capacity in a far better way.

Figure 1: From industry 1.0 to 4.0



Source: DFKI (2011)

Another application area of capacity optimisation innovation for a company is **launching a new plant or a new product**, which often is accompanied by adaptations, trials, pre-series testing requiring a high-calibre launch team, and numerous unexpected cost overruns. A day lost through a standstill of production means a revenue loss for many businesses. New technologies enable modern capacity optimisation software to use virtual plants and products to prepare the physical production design of the manufacturing project.

Every process is first simulated and verified through the software; only once the final solution is ready and the physical mapping done, are all software, parameters and numerical matrices uploaded into the physical machines controlling the production. Some initial trials have made it possible to set up an automotive part production unit in three days – as opposed to the three months it usually requires today. Virtual and actual plants can be designed and easily visualised in 3D using augmented reality technology. Monitoring the production rate, error alerts, and maintenance blueprints, as well as how the workers and machines will interact, is technology currently available at fingertips when using any tablet device.[6]

Plant design combined with capacity optimisation is a powerful combination, allowing for four key capabilities:[7]

• *3D factory design and visualization capabilities*, including parametric-based smart objects, that team members can use to develop the factory layout and identify early design issues.

• *Factory logistics analysis and optimisation capabilities* that team members use to optimise material handling, logistics, and indirect labour by comparing part routing information, material storage needs, material handling equipment specifications, and part packaging information against the factory layout.

• *Production throughput simulation capabilities* that provide you with the data necessary to make intelligent business decisions related to the required capabilities, buffer sizing strategies of the factory, and the ability to minimise capital investment while maximizing long term ROI.

• *Collaborative factory design management* that provides diverse teams with the ability to capture and communicate the factory model's design principles and standard resources in a collaborative environment. Other application areas of capacity optimisation are driven primarily by the **powerful data-driven analytics** through cheaper processing power. This can help to solve previously unsolvable (and even unknown) problems that undermine efficiency in complex manufacturing environments: hidden bottlenecks, operational rigidities, and areas of excessive variability. Similarly, the power of data to support improvement efforts in related areas, such as quality and production planning, is growing as companies get better at storing, sharing, integrating, and understanding their data more quickly and easily.[8]

In conclusion, capacity optimisation is becoming more and more relevant for manufacturing companies when machines and the Internet become connected. Not only does this generate new insights and possibilities in making production lines more efficient, but this also comes with increased complexity as trade-offs have to be made in choosing between priorities and sequencing in a limited workspace.[9]

The enterprises interviewed for this study have indicated to predict growth opportunities in their business space in the years ahead. They characterise their clients and independent research institutes as enthusiastic and willing to cooperate further to enhance capabilities, speed and simplicity of optimisation software. Riding the wave of Industry 4.0 and the advent of the Internet of Things, companies providing the information and communication tools necessary to make this happen will have a good potential to succeed as major companies and SMEs alike start adopting the technology.

3. Socio-economic relevance

In this chapter, we will consider the social and economic relevance of capacity optimisation. First, we will discuss the market potential of the trend and whether manufacturing companies are eager to adapt their traditional way of doing business. Second, we will elaborate on the benefits of capacity optimisation by introducing the five case companies that we selected. Third, we will explore the reasons why clients may buy services of these case companies, and what needs they have. Finally, we will explain reasons as to why clients may choose to wait for implementing capacity optimisation services.

3.1. The market potential of the trend

In this section we will discuss the drivers of capacity optimisation, which include economic conditions as well as the Internet of Things rapidly finding its way into society into the hands of consumers. Second, government investments will be discussed that support research and the infrastructure in order to facilitate rapid adoption of the 'Smart Factory' in general and capacity optimisation in particular. Third we will elaborate on the impact of capacity optimisation innovations on the environment as well as their impact on society, particularly addressing factory workers. Fourth, we will elaborate on the relevance of capacity optimisation, either for a select few companies or also for the bulk of small and medium-sized enterprises (SMEs) in the market. Finally, we will give a short introduction of the case companies. Table 1 below providers an overview of the company cases referred to in this case study.

"The development of capacity optimisation software allows for a better use of equipment, people, and processes" - ***Siemens Industry***

The current economic crisis puts pressure on the manufacturing industry and faces it with new demands. Factories require more flexible and efficient production processes that are also able to respond quickly to production errors and other adverse events to minimise the impact on their business. By making use of smart IT systems, factories can optimise the use and capacity utilisation of machines and production lines.

The earlier-mentioned Internet of Things is finding its way in the hands of the consumer through smartphones, fitness trackers, connected refrigerators, and communicating cars. The use of very small processors, storage units, sensors, and transmitters will be embedded in nearly all conceivable types of machines, products in mid-process, and materials. Together with smart tools and new software that allows for structuring of data flows, these innovations will enable products and machines to communicate with one another and exchange commands. In other words, the factories of the future will optimise and control their manufacturing processes largely by themselves. However, experts interviewed for this case study point out that it may take years to see the Smart Factory become mainstream in manufacturing.

Nevertheless, there are clear examples that national governments are taking the initiative to facilitate rapid adoption of new technologies in manufacturing environments. The German federal government has set aside approximately EUR 200 million to help industry associations, research institutes, and companies develop an implementation strategy. The U.S. government also develops its innovative manufacturing strategy. It plans to provide up to EUR 700 billion in funding for the establishment of a national network of research institutes and businesses.

Making use of digital technologies to optimise production processes is bound to be one of the core elements of large-scale uptake of the Smart Factory. Public authorities are responsible for making ubiquitous broadband networks available, and industry needs to put data standardisation and transmission protocol systems into place in a timely manner. This would allow products and services to be delivered faster, in different ways and at a lower cost to the consumer. Thus, capacity optimisation allows for a quantum leap in interoperability and configurability of production lines, resulting in customized production at any time and location, higher variance and shorter innovation cycles.[10] Governments are making sure that through targeted investments in the 'Smart Factory', smaller trends such as capacity optimisation can develop more rapidly.

Another relevant factor to society of **smart manufacturing in general and capacity optimisation in particular** is that input can be used more efficiently, thus reducing pressure on the environment. For example by using sensors, machines can be automatically turned off when temporarily unused. This has a positive effect on the usage of materials and energy in production processes. Producing using these so-called **lean manufacturing principles** creates an operational and cultural environment that is highly conducive to waste minimisation and pollution prevention. Lean methods focus on continually improving resource productivity and production efficiency, which frequently translates into less material, less capital, less energy, and less waste per unit of production. In essence, capacity optimisation is about using the most of what you have, thus helping to reduce environmental pressures.

The development of capacity optimisation software allows for a **better use of equipment, people, and processes**. However, when labour becomes more expensive and machines are capable to do more things in a shorter amount of time, people on the factory floor run the risk of becoming obsolete. Siegfried Russwurm, board member in charge of Siemens' industry division, says that computers and robots are not about to make humans redundant just yet. As production becomes more highly automated and connected, greater customisation will be possible, for which consumers will be willing to pay a premium so long as they it is delivered to them in the shortest amount of time. Russwurm points out that this can mean the cost in terms of logistics and the time to customer is more than the wage cost disadvantage of manufacturing products in a developed market, which makes reshoring of manufacturing from low-cost countries increasingly more interesting.[11]

Although mostly multinational firms have moved to embed capacity optimisation solutions in their manufacturing systems, SMEs also benefit from this innovation. The concept of a networked factory for is particularly attractive when a companies in a value chain that is spread across many locations. However, capacity optimisation solutions can also help smaller companies accelerate their production processes and make them more flexible, e.g. through the processing of real-time information.

Innovation, automation and sophisticated processes are at the root of industrial success strategies and have proven to be critical in maintaining a leading position. Reindustrialisation entails more than refurbishing old or vacant manufacturing structures. Complexity in manufacturing will be much higher and will require sophisticated marketplace offerings based on IT systems that are built around machines, storage systems, and supply lines that adhere to a defined standard and are linked up as cyber-physical systems (CPS).

Lean manufacturers are noticing the difference. The benefits they enjoy suggest that more big data applications will be finding their way into the lean tool kits of large manufacturers. These companies report an extra two to three percentage points of margin, on top of earlier productivity gains from conventional lean methods that often reached 10 to 15 percent. Indeed, it seems that, taken together, the new uses of proven analytical tools could be worth tens of billions of dollars in earnings (before interest, taxes, depreciation, and amortisation) for manufacturers in for instance the automobile, chemical, consumer-product, and pharmaceutical industries.[12]

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

Company	Location	Business innovation	Signals of success
Quintiq	Netherlands	Quintiq's unique value proposition lies in bundling all the components required to plan, schedule and optimise processes for any potential business model on a single software platform. The flexible core architecture enables users to solve their industry-specific planning and optimisation issues.	- Company has expanded locations within Europe (9 offices) and outside of Europe, from South-Korea to Australia, from Singapore to the United States. - The company is growing rapidly since its inception in 1997: more than 12,000 people in 80 countries use Quintiq on a daily basis - The coming years the company is looking to double in size to 1,400 employees.
Signavio	Germany	The Signavio Process Editor allows users to share process models and invite others to comment on diagrams, by: •Visualising, discussing and documenting processes; •Making process descriptions and related Standard Operating Procedures (SOPs) accessible in a process portal; •Integrating all employees in continuous process improvement; •Allowing the simulation of processes before the actual realisation in the organisation.	- Since its foundation in 2009, the company has served over 400 customers from around the globe. - International offices situated in Berlin, Singapore and the United States. - Signavio invested in cloudbased workflow engine Effektif, recognised by Gartner as 'Cool Vendor' 2014 and regarded as industry leader in several markets. Effektif now belongs to the Signavio group.

Metaio	Germany	Metaio is a global leader in augmented reality research and technology. Metaio offers a full range of services for organisations that want to integrate augmented reality in their processes, for instance by superimpositioning CAD models on images of the factory floors or production lines.	- Serving over 100,000 developers with over 1,000 apps for enterprise, marketing, retail, publishing and industrial cases, Metaio's AR software reaches over 30 Million consumers across the world. - Metaio is regarded as a leader in the AR software space.
Siemens Electronics Manufacturing	Germany	Siemens' electronics assembly plant exemplifies the factory of the future: Smart machines collaborate with each other without defects, downtime, waste or waiting. Plant managers and CIOs work together to create a seamless blend of data on production.	- There are more than 7 million licensed users using HD PLM Technomatrix. - 71,000 companies around the globe use Technomatrix and Teamcenter
Thinfilm	Norway	Thinfilm is the first company to commercialise printed rewritable memory and is now creating printed system products that will include memory, sensing, display, and wireless communication. Such integrated systems will make it possible to use electronic intelligence in applications where they have never before been affordable, even, for example, in disposable goods.	- Thinfilm is a market leader in the product of printed electronics labels worldwide. - They have presence worldwide and major manufacturing companies as clients. - Between 1995 and 1998, Thinfilm patented its core IP, resulting in a six-year collaboration with Intel to compete with NAND Flash. - Listed at the Oslo Axess market place on the Oslo Stock Exchange

3.2. The benefits of implementing Capacity Optimisation solutions

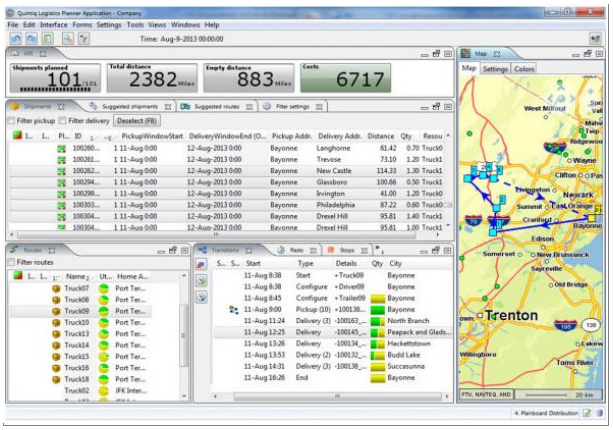
In this section we will address benefits of capacity optimisation through the lens of the five case companies that we have selected. We will enter into the problems their clients facing and how capacity optimisation engages these problems.

Problem 1 – every business has its planning puzzles, some large, some complex, some seemingly impossible to solve. In the traditional sense, businesses have focused on point-solutions for optimisation of their supply chain, which has resulted in a scattered landscape of different processes solutions per department and per group working group. Consequently, organisations lack a single view of the supply chain which hinders collaboration and transparency.

Innovation solution 1 – Since its foundation in 1997, **Quintiq** has been focusing on delivering a single-platform solution for businesses that aim to optimise their supply chain. Today, version 5.0 of the Supply Chain planning and optimisation software offers services in areas such as production planning, network planning and logistics, and workforce planning and scheduling. The core of the service revolves around optimisation technology, mathematical and constraint programming, as well as path optimisation algorithms, developed in cooperation with specialists from business and academia. Clients can access the programme in real-time with a very large number of users using it at the same time.

Quintiq software can be delivered to include the adjusted parameters for the value drivers and specific constraints in specific types of supply chains. Whereas other solutions traditionally take significant time and resources to be adjusted to specific client situations, Quintiq's solution is praised for its relative ease of implementation and minimal programming issues.

Quintiq's logistics optimisation software



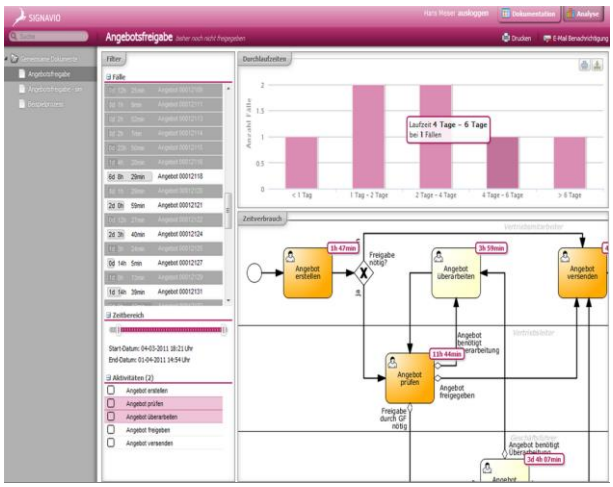
Source: Quintiq

Problem 2 – Business Process Management (BPM) plays an essential role in the manufacturing industry. Organisations strive to continuously improve their product quality and processes. BPM initiatives are more successful as more stakeholders get involved in process design, yet this is not always put to practice. Many businesses have to deal with complicated business modelling environments that in practice only the experts are using. This leads to process models that lack critical input and are hidden from key management positions.

Innovative solution 2 –**Signavio Process Editor SaaS** is a process modelling tool that is web-based; no computer software needs to be installed. Signavio's innovation is developed to allow professional process design, including adherence to BPMN 2.0 standards, XML round trips for process execution, simulation of processes, communication of processes and related documentation through the process portal, compliance and risk management, and detailed reporting that includes process cost calculation and resource requirements.

What is also unique about Signavio's innovation is its attempt at removing barriers to usage that some complicated process modelling tools have. Even employees with little to no experience can start designing process models with Signavio and collaboration is made easy as anyone granted access rights can view or edit the models. For example, managers with operating responsibility can capture, document, and share professional process models without investing a lot of time. Using QuickModel (a spreadsheet-like process design tool) even workers without any knowledge of BPM are able to create process models. These models can then be shared with BPM experts, who can further define the model in IT system terms or integrate the models to capture a full view of the organisation's processes.

Signavio's logo



Source: Signavio

Problem 3 – Due to the need for shorter product life cycles and the rising complexity in automotive construction and design, ease of comparison between actual prototypes and CAD 3-D models is key to reducing time and cost. But the quality of the related CAD documentation at the beginning of every new project can be unreliable. If plans are based on incorrect data, significant issues will arise during a new car model's integration.

Innovative solution 3 – Augmented reality (AR) is a type of computer vision that uses camera technology to recognise real world images, objects, and environments and superimposes virtual information and data onto reality in real time. It turns your smart device into a lens for adding video, audio, 2-D content, 3-D content, and location-based information to nearly anything.

Metaio Engineer is a powerful Augmented Reality tool for industrial application: from the visualisation of future facilities within a current production environment to deviation measurement between a CAD model and the related assembly part. Input for CAD models usually is prone to errors, so to minimise this risk, Metaio Engineer enhances and accelerates the process of verifying CAD data.

The superimposition of CAD models in photos of the facility enables visual comparisons. Based on the data, quality can be determined immediately. When used in combination with location markers, Metaio Engineer supports analysing deviations in equipment locations with a measurement feature to help determine the difference between real and virtual equipment and transfer this information into the CAD software in use. Also the extent of the deviation can be measured with the AR scene. In this way the Metaio Engineer replaced 3-D scanning when evaluating the current status of facility.

Metaio's Augmented Reality tool process

Source: Metaio

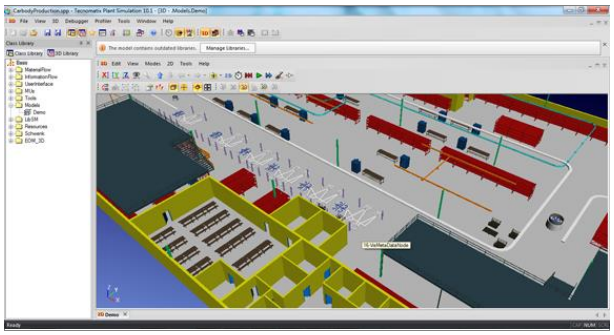
Problem 4 – Defects, downtime, waste, and waiting spells are inefficiencies that impact the bottom line of any company involved in manufacturing.

Innovative solution 4 – **Siemens**' electronics assembly plant in Amsberg, Germany, exemplifies the factory of the future, where smart machines collaborating with each other, and without defects, downtime, waste, and waiting spells. Plant managers and CIOs work together to create a seamless blend of data on production. For example, the standard range of switching devices comprises 40,000 products. So in order to set up production systems efficiently and at the lowest cost, engineers at the Amsberg plant plan the production process digitally from start to finish with Tecnomatix, a product lifecycle management (PLM) solution from Siemens PLM software.[13] This allows engineers to work out different production versions and compare costs, throughput, and other details, even in the concept planning phase. The software is supported by Teamcenter, a unifying database from Siemens PLM Software, which manages the entire product lifecycle digitally and is accessed by planners as well as developers and brings together all of the product-related information from planning, development, and production, to sales, service, and maintenance.

The across-the-board integration of data achieved by Teamcenter software brings with it huge benefits, as the time required to develop a market-ready product can be cut considerably, which not only leads to a competitive advantage but also reduces costs and the amount of energy and resources needed. The software can also be used to identify a product's potential effects on the environment.[14]

For a long time, Siemens has been a firm believer in the connected factory and in robotics to make production lines more efficient. The company has recently invested in highly flexible plants, steered by software, connected via sensors and the internet, and making full use of big data analysis.[15]Networking machines allows for a reduction in time-to-market, as the regulation of peaks and flows due to irregularities in the production process can be managed more effectively, sometimes up to 50% more.[16]

Example of Siemens' Product lifecycle management solutions



Source: Siemens

Problem 5 – While machines may be straightforward to integrate in networks, physical products or parts that move from production into the hands of the consumer are considerably more challenging to digitise.

Innovative solution 5 – **Thinfilm** is the first company to commercialise printed rewritable memory and is now creating printed system products that will include memory, sensing, display, and wireless communication. Such integrated systems will make it possible to use electronic intelligence in applications where they have never before been affordable, even, for example, in disposable goods.

Thinfilm focusses solely on printed electronics. The company headquarters are situated in Oslo, Norway, with product development, manufacturing and sales offices around the world, from San Francisco, USA, to Tokyo, Japan, and Pyongtaek, South Korea.

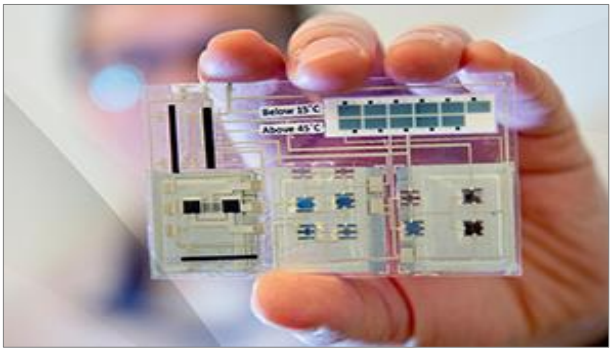
"NFC-enabled labels can enable a wide variety of applications, including ubiquitous, low-cost track-and-trace monitoring for temperature-sensitive medical products such as pharmaceuticals and vaccines, and food perishables such as meat, seafood and produce." – ***Thinsfilm***

Thinfilm announced a collaboration with EVRYTHNG (Evrythng.com), a software company that makes physical products 'smart' by connecting them to unique digital identities on the Internet. Through the agreement, Evrythng will integrate its cloud-based, software-as-a-service platform with Thinfilm's suite of printed electronics products, including the Near-Field Communication (NFC) barcode and Smart Label product families.

With combined expertise spanning printed electronics, NFC, and scalable cloud-based software, Thinfilm and Evrythng can combine tangible products or parts with digital profiles to encompass everyday items, including consumables. Users can connect directly to that product's digital identity for interactivity and functionality. Businesses will enjoy the benefits of enhanced visibility into supply chain activity and consumer behaviour, while consumers will enjoy real-time, personalised interaction opportunities, from enhanced warranty registration and recall notification to customized offers for the relevant accessories, upgrades, and related products.

Evrythng's cloud-based SaaS platform will be enhanced to support Thinfilm NFC-enabled Smart Labels, which communicate both unique ID and real-time sensor information. This can enable a wide variety of applications, including ubiquitous, low-cost track-and-trace monitoring for temperature-sensitive medical products such as pharmaceuticals and vaccines, and food perishables such as meat, seafood and produce.

NFC-enabled Labels by Thinfilm



Source: Thinfilm

3.3. Client side drivers for the uptake

In this section, we will explore the reasons why clients may adopt innovative capacity optimisation solutions, and what needs they have. Client side drivers include the simplicity of the solutions, the cost advantage they offer, and the relative ease with which they are combined with mobile and portable devices.

One of the key client side drivers for the uptake is the overall simplification of the solutions compared to its substitutes. Planning and optimisation of industrial processes is becoming a more complex task for businesses, but one that is necessary for continued growth and success. .

Web-based solutions offer a **cost advantage** for the user. The maintenance cost of cloud solutions are lower than heavyweight, on-premise solutions. Also, end-users can start using the product right away, and they do not need to perform complicated installation or administration activities. Due to the access via a web browser as the only requirement, employees of every level can edit the process models at any time. The increased trust that people have in the cloud also has accelerated the adoption in cloud-based services, yet has taken a lot of time to develop. The implementation of the smart-factory concept in general is often significantly less expensive than initially expected. In just over four out of ten companies, investments in Smart Factory concepts and solutions amounted to less than EUR 1 million.[17]

Having only a **single platform of all IT applications** that needs to be managed can lower the overall costs of operating a factory. Collaboration across departments, monitoring, and higher quality plans are sought-after advantages of having a single platform to run these solutions. They allow workers to respond quicker to irregularities and interferences from the outside. Error reduction is also seen as a benefit of using an integrated platform to develop the product and to optimise the production via a networked production line.

Augmented reality offers advantages over traditional technologies as it is more easily integrated in current mobile devices. Applications can be designed on several mobile operating systems, all from one software platform which increases adoption. Both the cameras and the processing power of tablets and smartphones have advanced sufficiently to carry out the tasks and functionalities required for augmented reality to be of added value in industrial optimisation processes.

3.4. Client barriers to uptake

In this last section, we will explore why clients may be hesitant to adopt capacity optimisation technologies. Important barriers include the extent to which manufacturing companies are ready and willing to adopt innovative capacity optimisation solutions, the large upfront investments needed to deploy them, and the specialised skills that their workers require to be able to operate them in a way that generates the benefits these solutions are capable of.

One major client barrier to uptake of capacity optimisation solutions pertains to the readiness of businesses to adopt new technologies such as web-based services, such as Augmented Reality. In 2009, Signavio was the first to offer a Business Process Improvement tool as a cloud service. Only in 2011, customers were ready to adopt cloud strategies for their business applications. Before that, Signavio had to work hard to evangelising the innovation.[18] The technology behind Metaio - Augmented Reality - is also considered as an emerging technology and quite early in its development in some industries. It is crucial to communicate the benefits and ROI of using Augmented Reality in order to build up a sustainable business. In the meantime, the only thing an innovative company can do to stimulate adoption is to attend fairs, workshops, and conferences, and speak to potential clients that seem eager to pilot new innovations.

Another limitation is that traditional production technology has to catch up with the possibilities that information technology offers, with large upfront investments required. Standardisation of applications is still a challenge in an environment where different applications cannot communicate with each other due to differences in their programming languages. However, replacing legacy IT systems can be a complex and costly task for companies. Also a mentality of 'if it is not broken, do not fix it' is a common reason for underinvestment in technology.[19] But the choice of not adopting new technologies can prevent companies to meet the new demands of their customers, especially since adopting such innovative solutions takes time and energy away from other business priorities. [20]

Adequate skills training is essential for the uptake of capacity optimisation innovations, as computer-controlled equipment and advanced software speed up processes and improve efficiency levels. If employees are not trained in the latest technologies used in their facilities, the advantages of expensive equipment will not be fully realised.[21]Operators need to understand new equipment and respond quickly and correctly when problems arise. Keeping state-of-the-art systems running efficiently is no simple task. They require highly-skilled employees who can work with sophisticated machines that include mechanical and electronic components as well as sophisticated software. All these components are highly integrated within networked facilities designed to maximise production with minimal downtime. [22]

4. Drivers and obstacles

There are a number of drivers encouraging and obstacles hampering the business development of the companies providing solutions for capacity optimisation. These drivers and obstacles impact both the companies developing these solutions and the adoption of these by users in a range of different target sectors. This section will highlight the key drivers and obstacles that have been identified for this case study. Rather than describing the development of IoT and its relation to capacity optimisation, in this section we have chosen to focus on the drivers and obstacles of the companies in this sector, especially start-ups.

All of the case companies were founded on the basis of a piece of scientific research where the results were of such value that commercialisation was the next logical step ***- PwC***

The most important drivers of innovative capacity optimisation companies include a sustained connection to academia, successful sourcing of high-skilled talent with the right technological specialisation, and finding appropriate launching customers that can offer a podium for successful innovation. The most important obstacle for these companies pertains to differences in labour law across Europe, which creates uncertainty for employers looking to expand abroad.

4.1. Establishing early links to research and maintaining them

The companies that were part of this case study all had a connection to academia in their early stages. Although the degree of scientific involvement varied per company, it is appears to be a necessary building block for innovation in capacity optimisation. In fact, one of the case companies, Quintiq, claimed that one of their critical success factors is that they have more than 25 PhDs employed for further enhancing the technologies and algorithms behind their optimisation services. They maintain a close contact with the university to source new talent as well as the latest on scientific discoveries around this topic.

All of the case companies were founded on the basis of a piece of scientific research where the results were of such value that commercialisation was the next logical step. Signavio's Business Process Improvement tool's first prototype was part of a research project at the Hasso-Plattner Institute in Potsdam. The project received world-wide attention under the name Oryx. The founders were so excited about the technical possibilities that they chose to develop a professional tool and to found a company around that. Signavio is still connected to the academic world by offering the Signavio Process Editor in the Academic Initiative to students and researchers free of charge.

Metaio has been engaging in scientific research projects since its inception in 2003, such as the EU sponsored research projects VENTURI (immersiVeENhancemenT of User-woRld Interactions) and DiFac (Digital Factory for Human-Oriented Production System), the latter being the development of an innovative, collaborative production environment (CME) for the next generation of the digital plant, targeted at SMEs.

Augmented Reality is a field undergoing constant redefinition, so maintaining proximity to research is vital,as Metaio shows. Accordingly, Metaio regularly contributes to the academic community by publishing in conference proceedings and journals. Moreover, Metaio provides two datasets enabling the objective evaluation of visual localisation and tracking methods for research purposes.

Similarly, Siemens invests 20% of its annual profits in R&D and has employed nearly 30,000 people in this area. Germany's National Academy of Science and Engineering (aca-tech) believes that new manufacturing processes will lead to a 30 percent increase in industrial productivity. As the academy points out, Cyber-Physical-Systems will revolutionise not only production but also mobility and healthcare. Peter Herweck, Head of Corporate Strategy at Siemens, explains that Siemens aims to play a key role in this process, as it considers itself the world's leading supplier of automation technology and industrial software systems. Therefore, Siemens has been expanding all of its activities related to vertical IT systems, strategically acquiring software firms to insource critical expertise required for engaging Industry 4.0.[23]

4.2. Sourcing key technical talent is crucial but not an easy task

The companies analysed in this report indicate that attracting talent is crucial to their survival. On top of an entrepreneurial mind-set, employees also need to possess the right technical background, in particular in computer sciences, applied mathematics, econometrics, and manufacturing logistics. All companies that we have studied source talent from the European Union as well as from outside of the European Union.

Most companies reported that they try to search for the right skills locally as much as they can, yet they also look for talent in the United States and in emerging economies. This indicates that, currently, not enough talent can be found within Europe to fulfil the skills needs of innovative capacity optimisation companies. The case companies indicated that they are trying to source locally from universities and through personal networks, but the combination of technical talent who want to work for a relatively small SME and fit the job profile proves rather scarce.

"We managed to prototype our product at a German car manufacturer in the beginning. In addition, funded R&D projects and early corporate partnerships accelerated early growth" **- Metaio**

4.3. Successful companies have gained early traction at world-class businesses

The companies analysed in this case study show that early collaborations, partnerships, and joint projects with larger, already established companies positively influences successful commercialisation of capacity optimisation innovations.

Quintiq's story started in 1997 when five computer programmers began work on a new scheduling application for one of the world's largest aluminium hot mill operators. The unique and sophisticated algorithms they created were pivotal to Quintiq's success and the basis of the company that was formed.

Metaio was created from an initial project with Volkswagen that later received a German grant with which the founders used to bootstrap their enterprise. Next to funded R&D projects, early corporate partnerships helped to propel the firm forward in its early stages.

Signavio managed to sell its services to Germany's largest health insurance companies, AOK. As an early adopter, AOK had a big influence on how the tools function and are designed today. The revenue from the services provided to AOK also secured the survival of the first 12 months of Signavio.

The early companies that make up Siemens PLM were one of the pioneers in Computer-Aided-Design, Computer-Aided-Manufacturing applications. Under the names United Computing and McDonnell Douglas's Systems Integration division, these companies were successful in launching software solutions to market, despite the large hardware investments needed at the time.[24]

"We keep a close relationship with local universities, one of the reasons being to attract the best talent" **- Quintiq**

4.4. Discrepancies in labour legislation across the European Union create uncertainty

One company indicated that hiring key talent in parts of the European, in particular Southern Europe, comes with more administrative challenges than in other parts, such as Northern Europe. Unequal hiring policies and legal protection of employees creates an uncertain position for employers with respect to being able to let go of employees that do not perform. There are cases where drawn out legal battles have toppled over start-ups because they were not able to cope with the costs of firing an employee. As a result, some of the case companies that we interviewed proved hesitant to employ talent abroad, or worse, choose not to set up a foreign office at all. Instead, they hire international workers in the country where the headquarters is located so they have increased transparency regarding labour laws.

Initiatives that address this issue are being employed in Germany, where companies are able to hire up to ten people flexibly with a temporary contract that features relatively light redundancy policies. This might also help to engage unemployment rates throughout Europe, although the potential negative social impact such arrangements may have on workers needs to be taken into account.

5. Policy recommendations

The drivers and obstacles described in section 3 and section 4 allow for identification of some of the key areas in which policy may be required. Nevertheless, existing policies are in some areas already in place. It is therefore worthwhile to fully consider the extent to which these challenges require further policy action.

We have deliberately focussed less attention on how to stimulate the implementation of IoT and its impact on capacity optimisation, since we believe that this is a more complex issue that requires involving stakeholders from business, academia, as well as policy makers. Rather we have focused in this section on how governments and institutions can stimulate the development of new ideas into innovations within companies that foster highly-skilled jobs and economic development.

Subsequent policy recommendations include harmonisation of labour laws with an aim to facilitate development of innovative SMEs, to allow innovative SMEs to engage EU grants with more efficiency by simplifying the process of EU research funding requests, and to continue to invest more in technical education.

5.1. Harmonise labour legislation to facilitate development of SMEs

Regarding labour protection legislation, differences exist across the European Union. In a number of European countries, employees are protected more heavily than in others, creating an imbalance in job opportunities in some countries and in the sourcing of talent for companies as well. These differences condition a defensive stance of companies with regards to hiring opportunities for people in local markets, because of the high costs associated with dismissal in these countries.

The Commission has been taking steps towards creating a flexible and secure working environment under the name of 'flexisecurity'. Flexicurity is a crucial element of the Employment Guidelines and the European Employment Strategy as a whole. Integrated flexicurity policies play a key role in modernising labour markets and contributing to the achievement of the 75% employment rate target set by the Europe 2020 Strategy.[25] More flexible and secure contractual arrangements, from the point of view of both employer and worker are seen as a key initiative in this regard.[26] However, further standardised approaches beyond identifying key initiatives in the Member States have not yet been undertaken.

5.2. Make the tender process for EU research funding projects more efficient

The companies in this case study have indicated that sometimes it is not worth to put efforts into research projects sponsored by the EU. This is due to the rather long decision times, large amounts of technical and administrative input required, as well as the relatively low success rates, and lead to some companies losing interest in responding to calls for proposals. The application process, approval criteria, and reporting schemes often do not match the realities of start-ups and seem to be more geared towards more established institutions.

5.3. Invest in technical education

Most of our case companies have mentioned the lack of recruiting possibilities in the early stages of the company as well as their current stage. Investing in technical universities and promoting studies is critical for start-ups in this sector, because without new talent locally, they have to hire talent from outside the EU which can be costly and time consuming.

The European Commission with the Innovation Union has adopted a strategy to create an innovation-friendly environment that makes it easier for great ideas to be turned into products and services that will bring our economy growth and jobs. To this end, skill gaps will need to be identified and addressed through inter-university alliances as well as through industry-academia collaborations and triple-helix efforts. Although education is the responsibility of the Member States, and even though skill gaps in the Europe are addressed in some cases, the Commission could increase its efforts to specifically address technical skill gaps.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Quintiq	Arjen Heeres	COO
Quintiq	Wim Nuijten	Vice-president Optimisation Technology
Metaio	Daniel Gelder	Senior Vice-president Sales & Marketing
Signavio	Katharina Clauberg	Head of Communications
Siemens Industry Software	Eva Potappel	Marketing Manager Benelux
Siemens Industry Software	Neil Dunsmuir	Vice-president EMEA Marketing
Thinfilm	Thomas Knutsen	Head of Marketing

6.2. Websites

Quintiq	www.quintiq.nl
Siemens	www.plm.automation.siemens.com
Metaio	www.metaio.com
Signavio	www.signavio.com
Thinfilm	www.thinfilm.no

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