smart industry

DUTCH INDUSTRY FIT FOR THE FUTURE

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SMART INDUSTRY

DUTCH INDUSTRY FIT FOR THE FUTURE

Smart Industries are industries that have a high degree of flexibility in production, in terms of product needs (specifications, quality, design), volume (what is needed), timing (when it is needed), resource efficiency and cost (what is required), being able to (fine)tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques

PREFACE

SMART INDUSTRY – DUTCH INDUSTRY FIT FOR THE FUTURE

The economic growth of the Netherlands depends on the export industry. We will also be increasingly dependent on productivity growth, if we wish to maintain and increase prosperity.
The strength of the Dutch industry lies in companies that collaborate to find solutions to social challenges using technological innovations and to market these innovations internationally.

However, a strong industry should not be taken for granted. We live in a new economic reality. The market in which the companies operate and collaborate is becoming increasingly international, the sales market is becoming more and more competitive and volatility is increasing.
We are in the midst of the fourth industrial revolution. Robots and production systems communicate with each other, analyse each process independently and can work separately on the relevant product. This offers great opportunities. Germany has been making groundbreaking steps with the "Industry 4.0" programme. There is also a huge challenge for the Netherlands on the interface between industry and intelligence. Together with TNO, the Ministry of Economic Affairs, VNO-NCW and the Chamber of Commerce, FME has taken the initiative to make Smart Industry a priority in the Netherlands. There is no time to lose. Smart Industry is the future.

The Dutch business community – large and small – has everything it needs to respond to this promising development and to join forces with the frontrunners. The Netherlands has a strong tradition of collaboration in networks and clusters. We have a very high quality ICT infrastructure that links our country to the world, and we are world-class innovators. In short, the Netherlands has the basis to play a leading role in Smart Industry.

But we must act now. This report is the prelude to a decisive and vigorous national Smart Industry approach, an initiative in which we must work with a broad coalition of companies, knowledge institutions and government. This requires a broad agenda that addresses business models, research, human capital and prerequisites in the areas of safety and standardisation. Smart Industry is the future. So we're going to set to work on it. We are working on the innovation that is necessary to maintain and strengthen the earning power of the Netherlands in order to become and remain fit for the future.

Ineke Dezentjé Hamming-Bluemink, President FME

VDL Nedcar

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INTRODUCTION

1

1.1 THE CHANGING FACE OF INDUSTRY

Two decades of rapid advances in Internet Technology are having a sweeping impact on the economy and wider society. Information and Communication Technologies are combining and converging with sensor technology and robotics to form an Internet of Things that will drive profound transformations of the industrial system. *"The 2014 Consumer Electronics surprised everyone, not so much for the smartphones and the classic highlights of the event held in Las Vegas, but rather for the presentation of the connected cars, wearable technology and devices that, thanks to Machine2Machine(M2M) technology and the Internet of Things (IoT), are becoming increasingly smarter"* (Telefonica, 2014). The 'connected car' scenario highlights some of the key impacts of the Internet of Things.

The info graphic in Figure 1 shows how the IoT is radically changing business and industrial processes, enabling entire new classes of products and services.

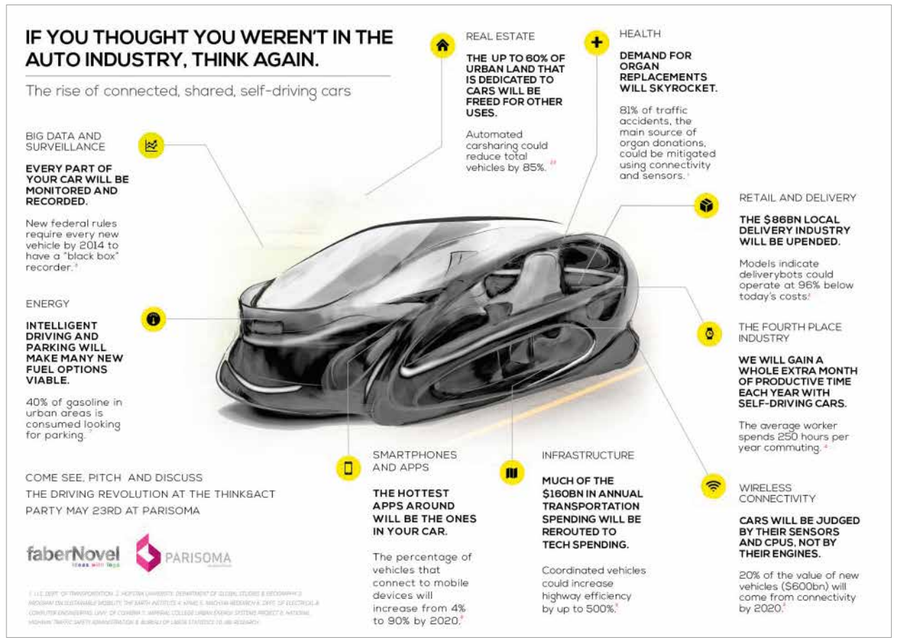
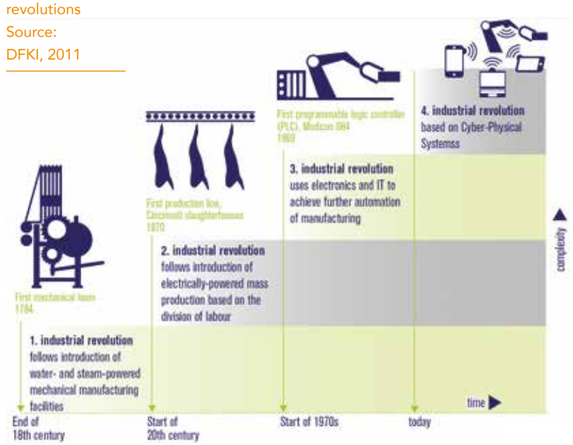


FIGURE 1
The Connected Car
Source:
Parisoma.com

It will decentralise production by enabling flexible, programmable and embedded forms of manufacturing. Real time Machine-to-Machine communication offered by the IoT will synchronise complex, high-end production systems, creating highly innovative value chains that cut across traditional sectors and domains. Advanced forms of manufacturing will drive the design of new materials, blurring the line between manufacturing and assembly, and Smart Industry will give a great push to lifecycle management and recycling (Made Different, 2014), (EFFRA, 2013). Critical to the Dutch economy is its excellence in a wide range of Business-to-Business (B2B) niche markets as well as its position in the agro-food domain fuelled by (production) efficiency. The Dutch industry can gain strategic advantage by combining smart technologies with Dutch 'soft skill' qualities like creative and innovative concept development, product-service combinations, client and business oriented solutions, integrated collaboration in value chains and, last but not least, open and informal communication.

Industrial revolutions
Source: DFKI, 2011



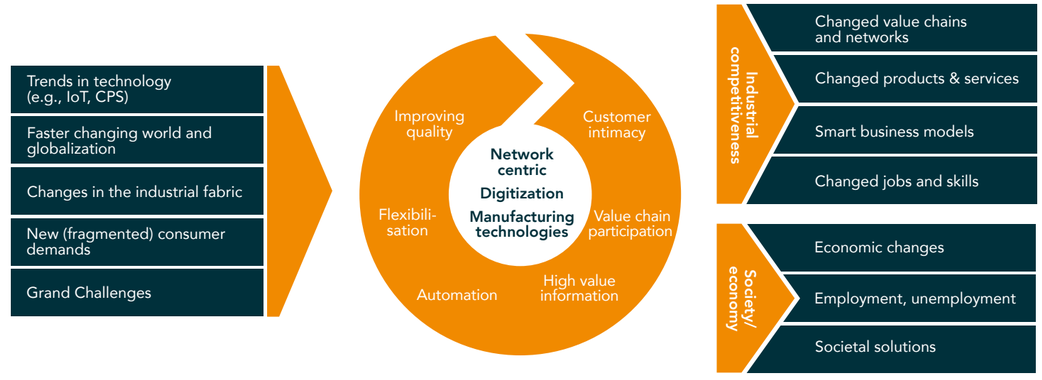
1.2 LOOKING BACK

During the first Industrial Revolution from the 18th to the middle of the 19th century, mechanical production methods were introduced, causing a shift from an agrarian, handicraft-based economy to one led by industry and machine manufacturing. The second transition at the turn of the 20th century brought industrial mass production, where assembly lines and factories allowed the creation of products for mass consumption. The most recent change at the end of the 20th century came with the deployment of electronics and IT in industrial processes and robotics, automating and optimising production lines with machines taking over complex, repetitive human tasks.

1.3 LOOKING FORWARD

Now we are on the brink of another industrial revolution, based on two decades of rapid advances in Internet Technology with a sweeping impact on the economy and society as a whole. Information and Communication Technologies are combining and converging with sensor technology and robotics to form an *Internet of Things* that will drive profound transformations of the industrial system.

Based on these **new technologies** and driven by new economic and social trends, the industry now faces another evolution that will **change its fabric** fundamentally. Technologies will enable **new ways of participation** and doing business, creating new products & services and providing new ways of organising production. All this is needed to create a future industry that can withstand the changing economic playing field, deal with changing market demands, and **address social challenges** in a such a way that we can still compete with the **fast growing international competitors**.



In the coming decade, **a network centric approach** to production will replace linear production processes with intelligent and flexible network approaches. These networks will interconnect parts, products and machines across production plants, companies and value chains at a highly granular level. Production in existing value chains will be radically optimised in the network centric approach, but, more importantly, the notion of network centric production finally spells the end of the 'value chain' and the birth of the 'value network'. This will result in new customer-centric business models, both at the level of organisations and across entirely new value clusters. Consumers and small businesses will co-create in a new and complex manufacturing system previously inhabited only by large companies. In this new ecosystem, new types of jobs will emerge, driving a demand for new skill sets.

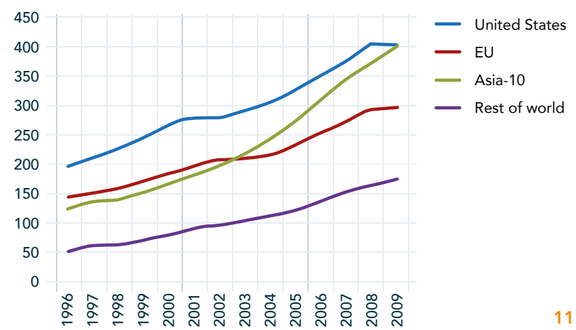
The value network will no longer be a PowerPoint fairytale but the blueprint of a next generation industrial system that we will call *Smart Industry*.

1.4 LOOKING CLOSER

The example at the start of this chapter shows a promising example of the impact of the Internet of Things, but there are more **technological trends** that drive the further development of this Smart Industry. Next generation adaptive robots, 3D printing, further integration of embedded systems, smart grid technologies, man-machine interfaces, cyber physical systems, advanced sensors, big data and cloud computing. These are all just examples of the enormous innovation-driving developments in technologies that are just around the corner.

There are opportunities to grasp based on technological developments, but the pressure is on. Our economy is also changing and putting pressure on the way our industry currently competes. Even more than in the past, **our economy is global**.

Global expansion of Research and Development Expenditures ($ trillion)
Source: NCSES, 2013



> INTRODUCTION

Asian economies are catching up with traditional leading economies like Europe and the United States, even overtaking them by investing in research and technology, with India also showing growth in research and valorisation (e.g. patents). It is also clear that Asia is investing more and more in research and technology. Where in the past, important breakthrough innovations would emerge from Japan, the United States and Europe, China, South Korea and even India are now showing growth in important patents. Since research and development is key to competitiveness, the conclusion can only be that our competitive advantage is under pressure. The good position of our present industry should not be taken for granted.

Another factor demanding a change in the way we look at manufacturing is the customer. **Customer needs have changed over the years**. There will always be a demand for commodities, but the new markets are about customisation and creating innovative new products. Customers not only demand high quality products, they increasingly pay for the experience or service, instead of just buying the product itself. It's not only about the relevance of a single product, but about how crucial it is to embed it in a broader context, including services. The Apple smartphone is a success, not because of its beautiful design and technological features, but because of its ability to run a huge diversity of apps. The downfall of Blackberry shows the importance of tailor-made apps. With the further development of a global economy and society, the world is facing major challenges. The European Commission has identified several Grand Challenges, which should be an important focus to governments, research institutes and industries. These **Grand Challenges** are instrumental in focusing the budgets from the Commission in, for example, the Horizon 2020 framework program for research, technology and innovation.

The European Commission distinguishes between the following Grand Challenges:

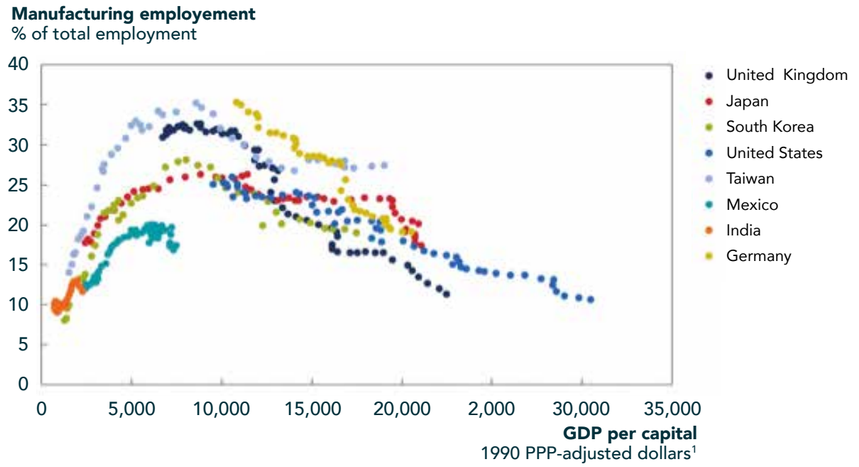
- Health, Demographic Change and Wellbeing
- Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bio-economy
- Secure, Clean and Efficient Energy
- Smart, Green and Integrated Transport
- Climate Action, Environment, Resource Efficiency and Raw Materials Circular economy needed
- Europe in a changing world - Inclusive, innovative and reflective societies
- Secure societies - Protecting freedom and security of Europe and its citizens]

Next to the related emerging consumer demands, the industry also needs to develop a strategy to address these challenges. Not only with new products and services that help solve these challenges, but also for incorporating them into their organisations. An example is ageing, which will lead to tensions on the labour market. How to deal with a shortage of good personnel?

All these trends change the **structure of the industry**. The moving of developing countries to leading economies puts pressure on what our manufacturing industry can and cannot do. Historically, it is common that economies that increase their income show a reduction in jobs in direct manufacturing. Often a shift towards a more service-oriented economy is seen, but these jobs are often manufacturing-related. This industrial shift has intensified due to the recent economic crisis. The limited availability of funding for innovation is creating an incentive to find funding elsewhere. Crowd funding is becoming an increasingly common and important way to finance innovation, but this implies that medium-sized and larger enterprises will have more difficulties finding capital for needed investments in innovation.

The driver of this shift is, of course, the low-cost labour in less developed countries. This is also happening in the Netherlands. Usually a differentiation is made between high-volume/low-margin and low-volume/high-margin production. High-volume/low margin is usually produced in low-cost countries and low-volume/high margin in countries where expertise and knowledge provide a competitive advantage. The result is that during the last decades mass manufacturing has partly moved to countries like China, South Korea and Vietnam. Bigger companies often moved production to the East. Others (mainly small and medium-sized companies) specialised as key players in all kinds of niche markets, as a supplier or as an original equipment manufacturer (OEM). However, during the last five years, a trend has appeared in which production is re-shoring to Europe as a result of the climbing wages in the East, improving productivity and other issues like communication and quality.

Low-volume, high-margin production also often refocuses business from cost reduction to innovation and creativity. Costs remain important, but innovation even more so. In its wake, a shift in smaller batches of products can already be seen as well as a demand to quickly adjust production to other products because of the fragmented and volatile markets. Agility is key, as is acting in well-organised supply chains.



Manufacturing's share of total employment falls as the economy grows wealthier, following an inverted U pattern
Source: McKinsey Global Institute, 2012

1 Adjusted using the Geary-Khamis method to obtain a 1990 international dollar, a hypothetical currency unit that allows intenational comparisons adjusted for exhange rates and purchasing power parity (PPP).
Source: GGDC 10-Sector Database: "Structural change and growth accelerations in Asia and Latin America: A new sectoral data set", Cliometrica, volume 3, Issue 2, 2009; McKinsey Global Institute analysis

1.5 THE DUTCH MANUFACTURING INDUSTRY IS CRUCIAL TO THE ECONOMY

Manufacturing is crucial to our economy. Manufacturing has one of the highest multiplier effects of all industry sectors, driving technological innovation and providing skilled and well-paid jobs (Mazarro, 2012). With its drive and need for innovation, the manufacturing industry helps address global societal challenges in the quest for sustainable economic growth.

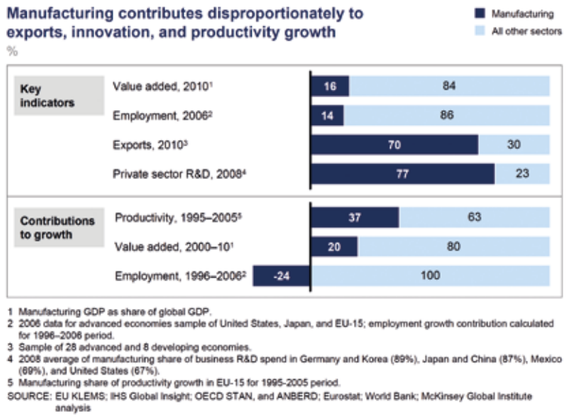


FIGURE 2
The value of manufacturing, worldwide
Source: McKinsey Global Institute, 2012

Business services and other non-industry sectors strongly benefit from demand generated by Industry. For every euro of EU manufacturing output, 34 cents of input comes from other supply sectors. The influence of manufacturing goes far beyond the direct contribution to GDP (13%) and employment (10% total workforce).

Manufacturing is a highly global business underpinning all economic activity. Industrial goods now make up around one-third of all Dutch exports, more than any other exported service or good (except for re-export from import - 41%). (Also see factsheet, page 40-41).

The added value of the Dutch manufacturing industry increases more rapidly than the industry as a whole, due in part to world-class performance in the Machine Building sector. Although still modest in size compared to some of its European counterparts, the Dutch manufacturing industry now ranks third behind Germany and Austria in terms of growth (ING, 2014).

In recent years, the decline in manufacturing output halted in the Netherlands, as it did across the EU28. The EU has set a target of increasing the industrial share of Europe's GDP from its current 15.3% to 20% by 2020, in an ambition to put Europe's industry back onto the path of growth.

We think that 'Smart Industry' will be a portent of a new era of manufacturing in the Netherlands and Europe. Implementation of the concept of Smart Industry can address the trends described in the previous section and will serve our society.

1.6 CORE CHALLENGE: FIT FOR THE FUTURE

Keeping up with the global economic trends and the fast growing manufacturing industries, especially in the Asian countries, requires action by the Dutch industry to sustain its competitiveness. Joining a global smart industry revolution will mean facing some tough challenges. With competition in Europe, USA and Asia heating up, Dutch Manufacturing needs to step up to the plate, making use of the new opportunities while building on current strengths. While there are signs that industry is starting to engage and world-class initiatives are taken by individual companies, we are not yet the frontrunners of tomorrow. The new breed of Smart Industries will need to deal with the high demands of the information society: outstanding quality, volatile consumer demand and competing with low-cost manufacturing countries.
How can we prepare the Dutch industry to be fit for the future? How to prepare the Dutch Economy for a future of Smart Industry? These are the central questions addressed in this report.

1.7 APPROACH TO THE STUDY

To address the challenges that Dutch Industry will face in a transition towards Smart Industries, an exploratory study was conducted by the Ministry of Economic Affairs, TNO, FME, Chamber of Commerce, MKB Nederland and VNO-NCW. The study aims to develop an opinion and make recommendations on Smart Industry. The study was conducted in collaboration with stakeholders from the Dutch Industry.

The study
The focus of the study is on the future of the Dutch Manufacturing Industry but also includes a bird's eye view of developments in the Agro-food, Logistics and Chemical Industry sectors. The study draws on expert research to investigate key challenges and their impact on Industry and Society. In three workshops and numerous interviews, key stakeholders, including Industry leaders, were consulted in order to identify the state of play in the Netherlands. The analysis produced a first outline of a national Smart Industry Agenda.

The study demonstrates that the developments driving the emergence of a Smart Industry are of great importance to the Dutch Economy. It is evident that Dutch companies are starting to engage with Smart Industry Initiatives; however, to ensure a competitive position in European and global markets, it is necessary and possible to do more and to do it now.


Marel

SMART INDUSTRY CHANGING BUSINESS

2

2.1 SMART INDUSTRY: NETWORK-CENTRIC PRODUCTION IN INFORMATION INTENSIVE ACTIVITIES

To face the challenge of being fit for the future, other countries have been developing strategies to build their industries to a level where they can compete within the global economy in the years to come. Most prominent for the Netherlands is the German Industry 4.0 initiative, but Belgium, Denmark, the United States and South Korea are also developing their own manufacturing strategies (See reference section table H4).

This report launches Smart Industry as an approach that makes use of the trends described in order to initiate a common strategy to develop the manufacturing industry further so it will be fit for the future. We define Smart Industry as follows, to be seen as a strategic vision of our future industry:

Smart Industries are... industries that have a high degree of flexibility in production, in terms of product needs (specifications, quality, design), volume (what is needed), timing (when it is needed), resource efficiency and cost (what is required), being able to (fine)tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques.

Smart Industry is built on three pillars:

- High quality, network-centric communication between players, humans and systems, in the entire value network, including the end-users;
- Digitisation of information and communication among all value chain partners and in the production process on all levels.
- Granular, flexible, and intelligent manufacturing technologies, adjustable on the fly to meet highly specific end-user demands.

In the coming decade, a **network-centric approach** to production will replace linear production processes with intelligent and flexible network approaches. These networks will interconnect parts, products and machines across production plants, companies and value chains at a highly granular level. Production in existing value chains will be radically optimised in the network-centric approach and, more importantly, the notion of network-centric production finally spells the end of the ‘value chain’ and the birth of the ‘value network’.

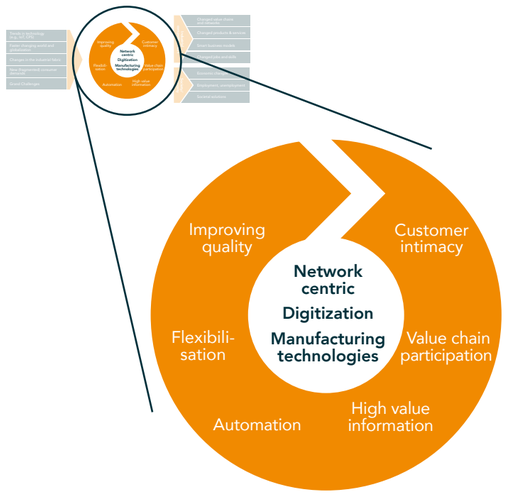
One of the key enablers of the third industrial revolution was the **digitisation of information and communication**. The Internet was instrumental in this, as was further software development. Digitisation is brought to another level within Smart Industry. Not only will it enable communication between all partners in the value chain, but digitisation of, for example, product quality, user-characteristics and production parameters based on sensory systems will also be crucial to new innovations in the production process, products and services.

The third pillar to Smart industry is about the next generation of manufacturing technologies. New modular approaches, as well as next generation robots, new ways of manufacturing (e.g. 3D printing) and ubiquitous sensors will enable cost-effective flexible manufacturing to meet the specific demands by customers.

2.2 INNOVATION DRIVERS CHANGING THE MANUFACTURING INDUSTRY

Driven by the trends described in the first chapter, we expect Smart Industry to be a result of changes on the following topics:

- Information as key value
- Customer intimacy
- Value chain participation
- Flexible production
- Improving quality
- Automation



Based on the next step in digitisation, a focus of business could be the use of **information as a new source of value creation**, since sensors and the network-centric approach will lead to an overwhelming amount of data. This information can be used to further align the activities within the value chain and improve communication between players. It can also be used to increase product qualities with new added services. With the help of smart sensors and IT, the manufacturer can predict the need for maintenance and can help customers all over the world with IT updates. The collection of all kinds of data (for example about the environment) can be translated into groups of new and unexpected (cross-sector) services.

Since customers will be more demanding, markets more fragmented and communication easier, interaction with the customer can increase and intensify, both qualitatively and quantitatively, leading to increased **customer intimacy**. The network-centric approach will also stimulate this collaboration with the customer; and through digitisation, the influence of the customer can even be translated into design and production using the new manufacturing technologies.

The key result of network-centric production is the boost in active **participation of all the partners in the value chain**. As said before, a non-linear value network will be created, allowing all partners to enter into a new way of highly interactive participation. Information is shared, production processes are aligned and cooperation evolves to a higher level.

Based on new manufacturing technologies, the next step can be taken **to produce in a more flexible way**. Using modular approaches, systems can be re-aligned, robots reprogrammed and systems controlled on even an n=1 basis (fully individual). Additionally, new technologies like 3D printing can facilitate cost-effective flexibility to a level never before seen. The combination with the other drivers mentioned above will lead to strong synergies and amazing opportunities. In the smart value network, value will be added to products by personalising them to the individual needs of consumers at very high efficiency levels, as well as individualised in B2B activities. The limit to customisation will no longer be set by technology but by the extent to which customers are willing to be involved in the design of their own products.

Digitisation will be taken to the next level. It is not only about sharing information. It is also key to further automation, together with next generation robots. New ways of pattern recognition, smart data modelling and computational technologies can even lead to fully automated facilities and to smart and automated ways to support production assistants. These trends will manifest themselves differently across sectors. In highly automated industries, visions of 'lights out' production plants and plants that run autonomously may soon become reality. Industries in which this is already seen are the production of bulk chemicals, the semiconductor industry and (parts of) food production lines. Assembly and packaging typically need more human attention. Jobs will continue to be created in the supply industry, in automation, in maintenance and in creating new business models, products, services and apps.

Massive data generated by sensors and communicated across the value network, in combination with information handling technologies such as big data, data mining and predictive modelling, enables better control of production processes. This results in **better product quality**. Enhanced control will drive defects to near zero levels. These technological developments enable industrial principles such as Zero Defect, Lean and Just-In-Time manufacturing to reach their full potential, while dramatically reducing cost and impact on the environment.

LELY

OEM of agricultural machinery
Chief Operational Officer Martijn Boelens

Lely has extensive knowledge of the processes and challenges of our customers - the dairy farmers - and we invest heavily to increase that knowledge continuously. Based on that data and with the creativity of our people, we constantly look for innovative solutions to improve the lives of our customers. We translate these ideas and solutions into products and services that we then develop and bring to the market ourselves: from pasture machinery and robotics & software, to concepts for energy-neutral dairy farming.

In order to continue to do this successfully in the future, we need good creative technicians as well as a very flexible production organisation through which other, new products can flow. We ensure flexibility by deploying our people effectively and adjusting the production cells easily. We require a good supply chain that is able to manage all our changes properly and supply new components at the right costs (lean). Through the constant urge to improve parts and processes, we preferably seek our suppliers in the wider region to ensure easy and fast communication. In this chain, ICT solutions will increasingly support communication and suppliers should be able to link to it.

2.3 FOUNDATION OFFERED BY ENABLING TECHNOLOGIES

There is no single technology or technology domain that governs the Smart Industry revolution. What we see is an alignment and convergence of rapid progress in multiple domains. **ICTs** that initially aided human-to-human and human-to-machine communication are now revolutionising machine-to-machine (M2M) communication, making machines more intelligent and providing them with a rich vocabulary.

Sensor technology will make devices aware of other devices and the world around them. Embedded systems will equip them with 'a brain' to process and communicate their observations. **Cloud technology and Big Data solutions** will collect, process, transport and store the massive amounts of information sensed and communicated by billions of devices. Advances in RFID and GPS will help track and trace each individual product. Together, these developments constitute the **Internet of Things**, an internet-style network of interconnected, intelligent machines termed **Cyber Physical Systems (CPS)**.

Creating robust and secure networks will be an important challenge for Smart Industry. New and more intuitive forms of **Human-Machine Interaction** will also play a pivotal role in managing secure and robust networks, and smart industry value networks in general.

VDL NEDCAR

Automotive manufacturing supplier
General Manager of Information Management Marcel Sieliakus

Striving to optimise its supply chain, VDL NedCar came up with the idea of a "warehouse-on-wheels". The central idea here is that assembled parts are no longer placed in the traditional warehouse; instead, individual parts are kept in trailers, eliminating the need for a buffer of automotive parts assemblies. In order for VDL NedCar to implement the warehouse-on-wheels idea, a highly collaborative software solution was needed. This was found in a collaborative software engine that operates as "pearls in a chain". A pearl chain is a metaphor for the production of orders and the way those orders are interconnected.

By offering transparency of these orders throughout the supply chain, the suppliers can easily align their stock and processes with the actual requirements of the OEM plant. From the moment the supplier receives the pull message via Electronic Data Interfacing, a trailer can be loaded with Just In Time or Just In Sequence deliveries.
As a result, the customer order now drives everything. The assembly plant or the supplier is no longer dependent on static forecasts; the assembly plant and supplier are no longer disconnected. Instead, the activities of both assembler and supplier work smartly in unison.

In the Internet of Things, CPS will gain a **shared situational awareness** to support network-centric production in two ways: (1) highly specialised, collaborative production of high-end commodities with minimal human interference, and (2) decentralised, design-driven, highly customised production involving local players including SMEs and start-ups.

Smart technologies have a significant impact on manufacturing processes. Flexible electronics and miniaturised devices integrating electronic and photonic sensors, free form optics, Micro-Electro-Mechanicals-Systems (MEMS) and integration of wiring, cooling channels and other elements in plastic parts will allow much smaller products with entirely new form factors. Flexible e-books and sensors integrated into clothing (wearable tech) will be among the first products in this line. Wearable technology was the buzzword at CES 2014.

In parallel to the ICT related developments, we are witnessing important advances in manufacturing techniques such as the rise of **additive manufacturing** (known as 3D printing) practical applications of which are enabled to a large extent by ICT developments. Additive manufacturing techniques require no moulds, which makes a single additive manufacturing machine suitable for creating a wide variety of products (reducing the costly process of reconfiguration and the bill for materials).

247 TAILORSTEEL

Supplier of metal parts
Director Carel van Sorgen

We traditionally still organise our work largely through the company (do it ourselves) or the market (outsourcing). The company is mostly scalable but less flexible. The market, on the other hand, is flexible but often less scalable. With this current way of operating in a highly competitive market, the time to market is often too long and the total cost of ownership is too high.

Since 2007, 247TailorSteel has worked continuously on the development and implementation of a 24/7 web-based portal, allowing customers to order their sheet-metal blanks and pipes on-demand via the internet. These developments allow 247TailorSteel to keep the cost of one single product almost equal to the cost of one product from a batch of 500 pieces.

However, we believe that it all can be shifted up a gear. This is why 247TailorSteel wants to initiate the Smart Bending Factory project, a new concept that involves more than just applying advanced information technology and optimising internal business processes at individual companies. The underlying philosophy is much more broadminded and innovative, namely simultaneously creating a community in which people collaborate closely, exploit resources together and share knowledge.

> SMART INDUSTRY CHANGING BUSINESS

2.4 BUT SMART INDUSTRY IS MORE THAN TECHNOLOGY

The previous sections mainly dealt with technologies, but this is too limited. Experience shows that the implementation of technologies for the purpose of benefiting from its opportunities takes special expertise and an innovative attitude. But Smart Industry is also about changing this attitude towards a customer orientation and acceptance that future competitiveness is about collaboration.

The technologies can facilitate, but implementation of Smart Industry takes guts, customer focus, strategic alignment of actions, an evidence-based focus, creation of anticipatory intelligence, thinking in leaps and bounds and acting in steps. It requires entrepreneurship and out-of-the-box thinking, as new players enter the field, not only as competitors but also as partners.

SMART- CHANGING SOCIETY AND INDUSTRY

3

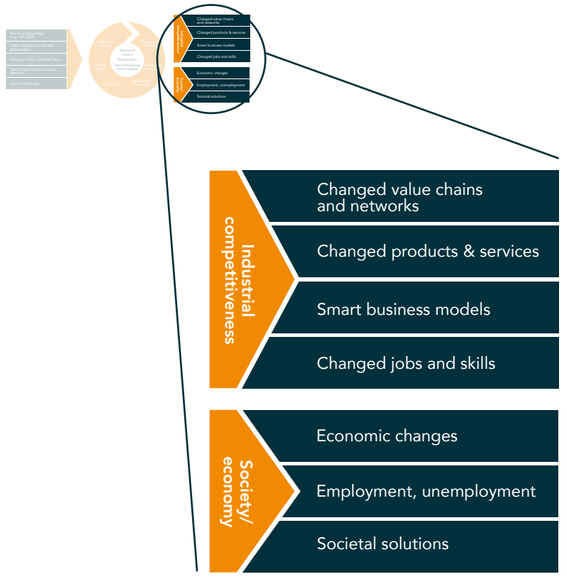
3.1 FROM DEFINITION TO IMPACT

The previous section described the definition and scope of the concept of Smart Industry. But what are the opportunities and threats for Dutch industry and Dutch society as a whole? Does it have the potential to increase the competitiveness of the industry and make it fit for the future?

As described, Smart Industry - driven by information, digitisation, networks and manufacturing technologies - will improve quality, increase flexibility, increase automation, enhance participation within the value chain and enhance interaction with customers. This has the following implications for the Dutch industry:

- Changes in the structure of value chains and networks
- New and adjusted existing products & services
- New business models to earn money, new competitors entering the market
- New skills needed and other jobs

Smart Industry does not only have implications for the industrial sector. It will impact the economy at large, and deals with some of the grand challenges our society faces. These implications will be described in more detail in the following sections. We will argue that the Dutch industry is in a good position to benefit from the opportunities Smart Industry provides, although there are also some threats to be anticipated. Of course, the actual impact will be determined by the actual actions of industry, research and innovation policy for the upcoming years.



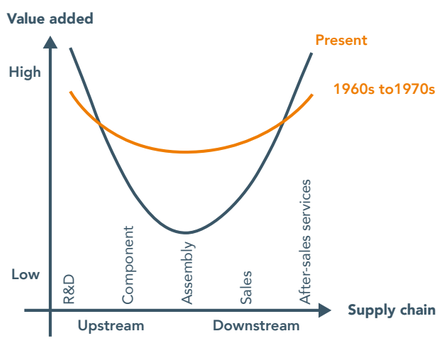
3.2 CHANGES IN THE STRUCTURE OF VALUE CHAINS

Since network-centric production is core to Smart Industry, it is not surprising that it will have a profound impact on value chains. Better communication and linking systems on a network level will change collaboration and even the way firms and other organisations will be organised in the value chain. This is enhanced by the further incorporation of aspects like customer intimacy and possible flexibility in production and products. It will impact the way production is organised on the network level.

- **Participation of customers during design**
- **Upstream participation**
- **Enhanced active communication**

An important first example is **participation of the customer**. Where in most cases the customer is just offered a product or service, Smart Industry and the corresponding concept of network-centric production will allow active participation in design and production. It will enable customers to discuss the options, even bringing in own designs (e.g. for 3D printing), and to share information while using the product. Other unexpected ways of use will become clear, as well as detailed feedback on the product, offering the opportunity to adjust and develop new products. Flexible production will even allow input from the customer to make adjustments during production. New value chain structures will emerge, shortcutting steps and entering new players in the game, such as open source non-professional designing customers. Innovation will also take place in the social networks (e.g. wisdom of the crowd), leading to new value chains that can produce these new and innovative ideas. This will even challenge the position of traditional leaders in markets.

The Stan Shih Smile curve
Source: Jason et.al, 1999



But more is to be expected. The "Smile curve" developed by Stan Shih in the early 1990s indicates that the method of earning money is fundamentally changing. Assembly alone does not create enough value anymore; Dell and Apple understand this well. And Smart Industry offers the opportunity to do more. Sales, even after-sales services, can become part of the job. Integrating sensors to collect data will provide valuable information for preventive maintenance and earnings with new services.
This **upstream supply chain integration** is a more general trend, seen in most economies. Farmers do not only produce food but also deliver it directly to the consumer or organise its delivery.
Smart Industry will not only facilitate this through enhanced communication, it will drive this trend. The result is a more diversified approach to doing business and retail having to rethink its role in the value chain.

A company traditionally organises its own business, of course with a reactive role to other organisations. This is set to change fundamentally. Smart Industry links companies in networks, with an active input in communication and organisation of the work of other organisations. Individual entrepreneurs have to shift their focus more and more to the added value of the value chain or network as a whole. Already, cloud services are emerging to organise information throughout the value chain, giving companies direct access to logistics information from other organisations - upstream and downstream. This approach is expected to be extended to information about manufacturing, enabling active intercompany influence on production. The result is that organisations will become more dependent and compete together as almost a single entity. On the other hand, open-source collaboration is becoming more important. An example is the use of open-source designs that can be used for 3D printing of specific products. Innovative learning algorithms will dramatically enhance collaboration in production work-flows, allowing last-minute changes in specifications for individual products while still delivering faster.

The question is what the possible implications of these changes will be to the Dutch industry.

Since national and international collaboration is an important characteristic of the Dutch industry, there are opportunities. Also, the focus on collaboration is in line with the Dutch *poldermodel* approach (the Dutch culture of consultation and deliberation). However, standardisation of communication and data exchange is crucial to efficient collaboration. This is not a trivial matter in the Netherlands, as standardisation requires consensus, and alignment to international activities is an option.

BRAINPORT INDUSTRIES

Cooperative of high-tech suppliers

Director John Blankendaal

As a result of global competition, technological complexity and increasing pressure on time to market, large companies can no longer do everything alone. In addition to the manufacture of modules, OEMs such as ASML, Philips Healthcare, FEI and Océ increasingly outsource development and engineering to strategic suppliers in the high-tech manufacturing industry. They ask the suppliers to bear full responsibility for these modules and also to carry out the development. This requires collaboration between the 1st, 2nd and 3rd tier suppliers in the chain. Innovation must come from the chain. Competition occurs more and more between chains than between individual companies. For this reason, the chain has organised itself in a cooperative enterprise: Brainport Industries.

Brainport Industries is a cooperative of 85 high-tech suppliers from across the country that collaborate to boost their innovative and competitive strength. New consortia of partners continuously arise within Brainport Industries. This does not mean that all 85 members always collaborate on a project. There are smaller groups that, depending on the request, organise themselves in projects regarding technology and process, market & chain or people & collaboration. An advantage of this is that people know each other and have made agreements on how to deal with each other through a code of conduct, which each member signs. One of the criteria for participation is that people are receptive to each other's ideas and prepared to share knowledge: collaborative innovation.

Why do these companies work together? Not to share costs! That is too defensive an approach; the point is that you can take more risks together than you could alone. It is driven much more by opportunities and is about the shift from "classic outsourcing" to "entrepreneurial collaboration".

The design-oriented activities connecting with customers are strongly supported by the Dutch industry and Dutch culture. The creative industry, especially the "design component" is strong; Dutch design is even an art movement. Many small firms, where freelancers often operate as creative entrepreneurs, are boosting innovation. Connection with the manufacturing industry is possible, but is now suboptimal. Here, the efficient and effective approach to manufacturing is limiting the opportunities. On the other hand, the high representation and active participation in social networks (e.g. Twitter and LinkedIn) shows that there are opportunities for consumers and businesses to connect. The strength of the IT service industry in the Netherlands and the crucial factor ICT plays in establishing Smart Industry provides not only a direct opportunity to develop the concept further based on existing skills, but also new indirect opportunities for the IT sector to export these new innovative capacities to other countries. New initiatives will emerge for small and medium-sized enterprises. The Dutch industry has a good track record of creating new larger enterprises from SMEs.

But there are threats. Especially retail and wholesale can be moved outside manufacturing value chains because of upstream integration. Since the Dutch industry is also a trade industry, the impact can be serious and should be further researched. Also, the fact that communication and information will become even more important than today also poses a threat. Because of its increasing value, hacking and misuse will have a higher impact. Entire value chains can be shut down and sensitive information can fall into the hands of the competitor. Also, enhanced sharing of information and participation of customers can lead to legal issues, such as who is responsible for production problems? Misalignment with (standardising) activities in other countries will reduce the opportunity for collaboration with international value chains. And since the industry is increasingly international, this jeopardises the Dutch position. Companies from other economies can then take their position.

MATADOR

OEM of hand trolleys and tools
General Director Paul Belgers

As a business in the manufacturing industry, you must be able to rely on both your suppliers and your carriers, and the entire chain should be transparent to the customer.

According to the principles of Lean Manufacturing, you do not begin with one step until you are sure that the next step will follow. There is no point in making something today when you can't ship it for another three days.
Actually, it is a destruction of capital, because one party adds value and the next in the chain lets it sit for three days, so it's actually better for the first in the chain to begin production three days later. This requires chain management, but chain management only makes sense if the companies trust each other and if there is transparency in terms of capacity and technical characteristics of the process.

This new way of working requires a different mindset from entrepreneurs. Transparency allows a quick response to customer needs. The alignment of the parties within the chain will also improve, which in turn will improve the competitive position of the Netherlands, enabling us to "recover" what we have lost to producers in low-wage countries.

3.3 NEW PRODUCTS AND SERVICES

All the changes that Smart Industry initiates have implications for the products that can be produced. Improved quality is clear; most customers reward high quality, especially from Dutch manufacturers. Flexible production leads to cost-effective diversification of the product. If a production line can produce smaller batches cost-effectively, the product portfolio will diversify. Even more disruptive is the increase of sensors in products, feeding back to the company and enabling new services to accompany products. But perhaps the most innovative trend is the previously mentioned participation of customers in the production process, asking them to come up with personal preferences or a completely new design.

- **Increasing product quality**
- **Diversification of products and customer participation**
- **Combining products with services**

In most cases, manufacturing will produce a batch of products, and **quality** is monitored by sampling*. The result is that variation during batches will hardly be noticed but will still occur. Using sensors, many products can be assessed on quality, leading not only to early identification of defects but also to a better understanding of the flaws in production. Production systems will be self-learning and bring zero-defect production into reality, which is a highly awarded component of Smart Industry. In addition to this, connecting to the user can be utilised to better understand what the user wants. What if your product comes with an app to manage your product but also asks for feedback? All users of your product will then act as a living lab, providing you detailed suggestions to improve your products. And why stop at the user? Why not integrate this approach through the entire value chain?

The trend to combine products with services is strong. Both the network-centric approach and the increasing intelligence of products provide opportunities for additional services. Today, the products produced by ASML are accompanied by training and maintenance.

Increasing flexibility and automation will have an enormous impact on the kinds of products that can be sold. Diversification, diversification, diversification. Mass customisation was coined during the late 1980s but has only gained momentum in the last decade. Robotisation and better communication increased the possibilities to have a direct connection between the producer and the customer and it is to be expected that this will be boosted again by Smart Industry. 3D printing and other robotised manufacturing methods will make production more flexible on one side, and

* *This is different in the case of critical products, like, e.g., in aerospace, defence and healthcare.*

social networks will further enable participation of the customer on the other. Why not share social experiences directly in order to create new products! The result is further diversification at a level that is still very much unknown! N=1 can be achieved. Why not support the customer in manufacturing a dress they designed themselves! This is already happening on a large scale with books, as Océ printers facilitate the manufacturing of one book at a time. It not only reduces stock but also facilitates the trend of consumer fragmentation.

But diversification requires support. Support by the industry with technological infrastructure and support by services. It is not easy for individual customers to get into a participative mode, so a little help is needed. However, new services are not limited to the design. Enhancing the information part of a product and the production system also enables better services. Incorporating sensors in the product that monitor operation, which results in advanced remote maintenance. Although this is already happening, the network-centric production will boost this to another level, connecting throughout the entire value chain. A service to find improvements in logistics based on big data, selling light - not light-bulbs, using pattern recognition to predict the market, placing fully serviced small chemical factories at the client location. All are just a few examples of the opportunity that Smart Industry provides for new product-service combinations.

It is clear that diversification of products means new opportunities. The new, more demanding customer not only rewards tailor-made products but also participation in the production process. And it links up with the character of the Dutch manufacturing industry, where it is often about niches and high quality. However, it should also be noted that this flexibility will be limited to families of products; a car manufacturer cannot produce children's toys economically (not even when it is a Dinky Toy). And there are exceptions to the rule. We do have some highly automated manufacturers of high-volume products and we should also address their needs in Smart Industry. The Dutch culture of design, open interaction and service can be used to further get into this next generation of mass manufacturing and diversification of products. Smart Industry will also facilitate the further connection to the global economy, enhanced by the flexibility in manufacturing and reduction in costs of smaller batches.

The connection of products and services is supported by the Dutch industry. It always has been innovative, creating new markets and getting into emerging ones. Also, the strong presence of a service economy will contribute to its potential. However, the Dutch culture, although at the top of the EU, is lagging behind in entrepreneurship as compared to, for example, the United States. And although innovation is considered important, opportunities for young entrepreneurs could be improved and, based on the EU innovations scoreboard, it can be seen that existing companies have difficulties in making optimal use of the vast opportunity to bring new products and services successfully to the market. The connection to apps is a hot topic in today's economy, so having a strong app economy in the Netherlands helps, as does the focus of the manufacturing industry on value chain participation, big data and quality.

3.4 NEW BUSINESS MODELS

Business is about creating value. Traditionally, the underlying business models are either about competing on costs or competing on innovation and quality. In the manufacturing industry, money was made primarily by selling products to the next

organisation in the value chain - OEMs or resellers. Two challenges arise here. In network-centric production, it is not always clear who the next organisation in your value chain is, and the previously mentioned Smile Curve shows that just assembling parts into products is no longer the most profitable thing to do. It is about sales and after-sales, as well as the production of components.

One example is the trend of providing a service where a customer pays for the results (prints) instead of buying a device (printer). Companies like Google and Amazon are even providing cheap devices as Trojan horses to sell content (e.g., Chromecast, Kindle). Manufacturers increasingly lease their product to a customer and provide a service, e.g. remotely monitoring the status and maintenance, and they take back and recycle the device (circular economy) at the end of its lifetime. Over time, the value provided will shift from the device itself to the networked ICT with its databases, up to date information, etc., and the device can be replaced the moment the customer requires another service level.

But Smart Industry is more than this. The ever-increasing value of information is changing the industry. Information is money. And broadening the scope of a single organisation to the entire value chain, enhanced by robotised and flexible production, shakes up the view on business.

- **Acting as a network entity**
- **Creating value through information**
- **Continuous innovation**
- **Trans-sector collaboration**

Perhaps the most important implication of Smart Industry is that organisations will increasingly **act as a network** instead of a single company. The connected network-centric approach allows optimisation of networks instead of optimisation of a single company. Smart Industry is also about a better understanding of the costs in the entire value chain. So, investments in company innovation will be distributed throughout the value chain, thereby reducing risks. The huge investments by Intel and Samsung in ASML research are just one example. The benefits of investments can now fall back through the entire value chain. On the other hand, the costs of CO^2 emission rights can be shared among the partners.

Including more sensors in products and manufacturing systems will also create **valuable information**. The business model can be adapted based on this information. Information about customer use will feed into design. But perhaps the most important impact is the previously mentioned **creation of services**. Development of products can lead not only to accompanying maintenance, but also to other services. Like the farmer, producing not only ingredients but also a great recipe. This could even include selling the information to the hospitality industry. This information is of high quality and has rapid “refresh rates”, creating opportunities for dynamic pricing of goods. So the money is not made in selling the primary product, but by selling accompanying information.

An important element of these business models is the **continuous innovation** of goods and services. As the network-centric production enables more opportunities and the flow of information grows to an unprecedented level, new opportunities will continue to emerge. Competing in the global market requires continuous innovation and anticipation of these opportunities. Vast initial investments in flexible production and human resources are needed to anticipate this continuous stream of possibilities. If a new opportunity presents itself, the organisation should not need to develop a new production line. This will take too long. Production should be flexible to quickly address these new markets! Multi-disciplinary skills to deal with these dynamic markets need to be present, along with the technological capital (machines). The business model is increasingly about rapid and innovative response to new opportunities.

And the value chains are further expanded to non-traditional partners. Collaboration with newcomers and non-manufacturing firms is increasing as information becomes important. The data-dominated Google now shows interest in more hardware-oriented activities. Not only because “they can”, but also because of their strategic importance, like the Google Driverless Car. In the manufacturing industry, it is important to sell both software and services; it is about complete solutions. Other examples of this **trans-sector collaboration** are toys connected to gaming platforms, insurance companies investing in product development (monitoring of the disabled) and the famous Philips-Douwe Egberts collaboration in Senseo pad-based coffeemakers.

The openness and willingness of the Dutch industry to collaborate with other disciplines as well as the system integrator mentality foster these developments. Based on a history of international collaboration, the Dutch industry is also well suited to finding new partners for new business. However, the Dutch industry focuses more on innovative expansion of markets and innovations in manufacturing and less on creating new markets with young entrepreneurs. Seeking a combination with the Creative industry should offer even more opportunities. The Dutch Design Academy is a world-famous driver for these innovations.

However, these changing business models are complex. Both the information component and the network-centric approach can give rise to legal complications. How to protect data and data protection? Who is responsible if problems occur? How to deal with trade restrictions? What about privacy? Legal safeguards need to be developed, e.g. protecting corporate data. Standardisation is also crucial.

3.5 JOBS AND SKILLS

It is clear that Smart Industry will have a changing impact on the skills needed. Automation through robots and emphasis on flexibility reduces the repetitive low-skill work, but increases the need for more specialised work to reorganise the manufacturing systems and perform maintenance activities. Also, the increase in information and interaction with partners requires employees who are more experienced in IT and communication.

- **Impact on jobs needing low and medium skills in production**
- **Increase in jobs needing high skills in production**
- **Need for management and sales expertise**
- **Need for process engineers (instead of craftsmen)**
- **New services, ICT and data science**

As stated, robotisation will have a profound impact on the jobs in the manufacturing industry. Driven by cost reduction and increase in quality, especially low-cost labour could be fully replaced by machines in some industries (lights-out factory). However, it

is not to be expected that this will be widespread in the next few years. Yes, the developments in robots are on a fast track. Look, for example, at the plans of Google and Foxconn to develop a lights-out production facility to manufacture smartphones in the US and the impressive Philips factory in Drachten to produce electric shavers. But humans are still by far the most flexible production "factor". So, as smaller batches require higher investment and specialised production systems, especially in assembly, robots will often mainly assist production personnel and remove some routine work. But this can also change rapidly. For example, a Dutch company named Cellro is putting a lot of effort into making complete robot cells for smaller batches. This will go beyond replacing routine work. A full impact study is needed to get a clear view of the overall impact.

And besides this, more flexible manufacturing systems will need to be reconfigured and will require more maintenance. These are just two examples where an increase in jobs can be expected **in production**. Although automated, these systems are sophisticated and complex, and need to be operated. These are medium or highly skilled jobs that require technical expertise since the technology will be more demanding. Activities include troubleshooting, adjustments, software upgrades and greasing. Further development of supporting technologies and procedures can help semi-skilled workers to do this work.

PM-GROUP

Supplier of precision metal parts
Business Development Manager Joep Lüth

For the PM Group, Smart Industry means sophisticated logistics, versatility of employees, quick and accurate information supply, and excellent collaboration between people, machines and robots.
We recently conducted research into what production methods we need to apply to be internationally competitive in the assembly of our miniature linear guides. In the current process, these high-precision guides are manually assembled.
In our market, flexibility and short lead times are key success factors, and the analysis revealed that automation must be stepped up in order to remain competitive in the long term. Flexible and smart robots (vision and inline measurements) will have to be integrated into both standard and special assembly lines.
This does not mean that we need fewer people. On the contrary, in order to work effectively on increasing productivity, shortening lead times further and guaranteeing quality and reliability of delivery, we need many more people. But they must be people who are versatile and who can work with automation.
For us as an organisation, this means that we must invest in the knowledge of our employees in the areas of production preparation and automation.

The increase in participation in the network will also lead to a significant increase in highly skilled labour. Certainly, information systems are automated, but **management and planning** are becoming more complex and intensive as not only the management of the firm needs to be considered, but the connection to the partners in the value chain is also crucial. Forecasting production focuses not on mid-term developments, but is more sophisticated due to increasing availability of customer and partner information. In addition, dealing with the dynamic and innovative markets requires an innovative mind-set and specific expertise. Also, data experts will become more important, as more and complex data will be available for decision-making.

Outside the production firm, growth can also be expected in highly skilled labour due to customer participation and new services. It is to be expected that some non-manufacturing industries will experience job growth, like the creative industry (e.g. design), IT industry (new networks and IT services) and education. 3D printing will allow customers to develop their own design, but this must be facilitated since the typical customer would not know where to begin.

To be able to compete internationally, to take advantage of market opportunities and to answer the needs of Smart Industry, there is a clear need for more highly skilled technologists. However, it's not simply a question of increasing the number of technologists per se. There will be a shift from the need for 'traditional' engineers to process engineers and especially for IT workers. Computational thinking and computer science will be very important in the fourth industrial revolution. Sectoral, regional and national programs that aim to promote technology should therefore focus especially on ICT and computer science, both in schools and in the existing workforce.

It is to be expected that the disciplines, expertise and knowledge of today will not be sufficient for the Smart Industry worker of tomorrow. In general, companies already point out that the skills training provided by the educational system do not match the skills needed. The coming changes in the industry will increase this unbalance. Also, the opportunities can only be taken if there are entrepreneurs with the skills to bring them into innovative products and services. The slightly risk aversive Dutch culture can be a threat, as Smart Industry is about acting fast. However, the Dutch creative industry provides a further stimulus to take the opportunities. And the multidisciplinary culture in the Netherlands supports this.

3.6 CHANGING THE ECONOMY

The long-term impact of Smart Industry on economic structures and underlying value chains will be diverse but decisive for the future of the Dutch industrial landscape. What is clear is that mass production will not vanish, as the supply (i.e. manufacturing) of large volumes of certain products will still be more efficient in economic, environmental and social terms (commodities) in order to meet demand.
In the next decade, the difference in labour cost will be further diminished. Since the cost of machinery will be equal and remain lower and energy costs remain more or less similar for all competitors, the cost of transportation will become increasingly important. Smart Manufacturing can then contribute to re-shoring, as it further reduces labour cost.
A subsequent re-industrialisation of Europe might take place because of these proximity benefits.

But Europe will also be better positioned to develop and manufacture products with high value added in low volumes. Not only the "Made in" argument

is to be made, also the better quality of production and the more innovative culture also need to be considered.

In general, there will be increasing participation of smaller companies due to the opportunity of fast-track innovation that is enabled by customer demand/participation and flexible manufacturing. But these smaller companies can be expected to grow, as they will increasingly facilitate the production of families of products.

3.7 EMPLOYMENT

So what can be expected of Smart Industry in terms of overall employment? This is very unclear for reasons of complexity and unpredictability. What is clear is that both the overall number of jobs and structure of employment in the Dutch industry are likely to change.

First the number of jobs. Although automation might initially lead to a reduction in jobs, an overall reduction of employment is not all that certain.

THOMAS REGOUT INTERNATIONAL (TRI)

Supplier of guidance systems
Director of Operations Ruud Keulen

In the market in which TRI operates there is a strong need for manufacturers who are capable of delivering customer-specific products in relatively small series, in a very short turnaround time and with a high degree of flexibility and quality. This seems like an obvious list of demands, but it boils down to the following: a large number of customers within our market do not have a constant flow of orders. They often tender for projects with multiple providers. If they win a project, they have to have products quickly (<3 weeks). These products are not standard products, which means that there is no stock on hand. Order sizes range from 250 items to 10,000 items.

What this means for TRI is that there is not much of a base load for the production organisation. Our order horizon is < 8 weeks. This poses a challenge in terms of flexibility of the production capacity. Sometimes we need to scale up production enormously (>30%) and sometimes we need to scale it down. This requires a new organisational structure (self-management and flexible working). There is a technical challenge: in-flow manufacturing with a minimal order lead time (<4 days). This demands a lot from planning technology and a great deal from the rapid exchange systems, information technology and knowledge and skills of people (versatility).

Because there is no stock and a high delivery reliability, the quality must be high in terms of FTR (First Time Right). Manufacturing it right the first time is the only way to control costs.

Philips Consumer Lifestyle

History tells us that an increase in labour productivity tends to lead to additional jobs in other places. Like the manufacturing of the robots that facilitate the automation. A recent ITIF study predicts an increase of about 150,000 jobs in this sector in the US alone. And as already mentioned, robotisation can lead to re-shoring because the labour costs will be a less decisive factor in the overall costs. Also, an economy tends to create new adjacent jobs, as it also provides new opportunities (jobs in web design, new services, product design, etc.). What is certain is that not acting on the opportunities provided by Smart Industry is very risky. If no action is taken, the Netherlands will lose its competitive innovation advantage. Industrial activities will be shifted to other regions in the world that are more suited to compete on labour costs, creating job loss.

What is also to be expected is a shift in the demand for the type of worker in the Smart Industry. Although semi-skilled personnel will still be needed, it is expected that fewer of these jobs will be required. And, on the other hand, semi-skilled and highly skilled jobs will be created, and some will be replaced. But our industry is already facing a shortage in the supply of highly skilled technical workers. Education also does not seem to fit the requirements of the manufacturing industry.

MAREL

OEM of food processing systems
Global Manufacturing Director Fred Vijverstra

Marel manufactures worldwide and strives for local supply chains close to the customer.
Manufacturing/purchasing decisions in the supply chain are not only made based on cost price, but on total cost and the added value of suppliers.
The following three subjects play a role in the future: Automation, ICT and People. People are central and automation and IT are the foundation.
Automation refers to the robots, which can weld and mill 24/7. Assembly is still purely man's handiwork because of the high mix and low volume. The human factor continues to be of paramount importance in the automated cells too. Self-managing teams work in "cellular manufacturing" and only produce what the customer requests: one-piece flow.
ICT supports automation in production and product development. Product innovation is the driving force at Marel. ICT supports the alignment of processes: product development (3D model-based definition) automatically moves to production.
The human factor means the continuous training of existing and new employees. Automation has not resulted in fewer jobs at Marel, but in another type of work and, therefore, other required skills such as more programming of robots and planning on the shop floor. Along with companies from the region, Marel has set up specific training programmes in order to train people itself. Marel wants to enable people to move on to other jobs in order to keep their work attractive.

So, with present policy, Smart Industry will lead to increased shortages in the medium to short term. The government should subsequently intervene and prepare the workforce so that it is well equipped to handle the demands of the changing modalities in production. Next to the technical skills, the so-called 21st-century skills (e.g., creativity, entrepreneurship and collaboration) are also increasingly important.

But what needs to be kept in mind is that, in the longer term, ageing will also have a serious impact on the labour market. Not only fewer people will be available to do the job, but especially the physical skills will change. This can counteract some of the implications of Smart Industry for employment.

Despite all the unknown aspects, we do see that smaller series manufacturing will soon be possible by, for example, 3D-additive manufacturing, and due to the inherent higher costs of transport/logistics of small series, manufacturing will be increasingly concentrated in a region. This is the re-shoring trend that moves manufacturing back to large economic centres where proximity and interaction with the market results in faster response to changing needs. This will not compensate for previous losses of jobs. However, we expect that many new jobs for semi-skilled labour will arise for the distribution of goods to regional consumers and business.

3.8 SOCIETAL SOLUTIONS

The Grand Challenges are considered important to the further development of the European society at large. Here, too, Smart Industry can provide solutions.

As mentioned above, Smart Industry can contribute to the problems our society faces with regard to ageing. In the medium term, the working population is expected to shrink, and the average worker will be older. This calls for an adjusted workplace. In the medium term, increased robotisation and flexibility could support this changing labour force by robot-supported work. However, in depth research is needed to create clarity on this.

Especially in healthcare, further development of Smart Industry in pharmaceuticals could lead to the next step in personalised medicine. A flexible and network-centric approach to manufacture drugs can link the special needs of the individual patient to the production of individual dosages and components. This would enhance the effectiveness of drugs. Using the same approach, it would also lead to personalised food, with nutritional value in sync with personal needs.

As regards the challenges in food, water and bio-economy, Smart Industry can also contribute to more efficient agriculture (e.g. precision farming), enhanced food security through the network-centric and information approach. The production of bio-based products could benefit in particular, as added value will be increased due to the production of more niche products.

These are just some examples of the Smart Industry opportunities to solve important grand challenges. A more in depth analysis is needed to provide a clear view.

FACTSHEET

Added value:

- Cumulative added value of manufacturing 13% of GDP in 2012 (CBS).
- In absolute figures: GDP of €540 billion, total manufacturing €68 billion (CBS).
- The Netherlands has high productivity in the manufacturing industry in Europe: €51.9 additional value added per additional hour worked (Eurostat).
- The competitiveness of the Netherlands and its supporting innovation system is considered high. On the Global Competitiveness Index 2013 of the WEF, it is positioned at number 8.

Export:

- 50% of total production in manufacturing industry is exported (CBS).
- Over 80% of total exported goods (without re-export) comes from manufacturing industries (CBS).
- Germany is the main export country (25% of the total exported goods). Other important export partners are Belgium (11%), France (8%) and the UK (8%).

Jobs:

- 10% of Dutch workforce in manufacturing industry (825,000 people), which is lower than EU average (Eurostat).

TABLE 1

Labour productivity 2012, as defined by euros of additional value added per additional hour worked

	Manufacturing	All sectors
Netherlands	**51.9**	**44.8**
Germany	51.4	41.2
Belgium	51.2	46.8
France	41.9	45.7
Spain	37.5	31.9
United Kingdom	36.8	35.0
EU-28	32.4	31.5
Italy	30.6	32.4

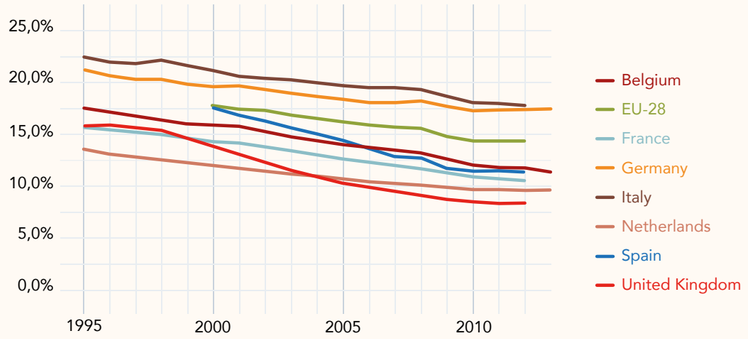


FIGURE 1

Employed persons in manufacturing (% of total)
Source: TNO based on Eurostat

Companies:

- The ratio between micro, small and medium-sized, and large enterprises in the manufacturing industry is 15%:53%:32%. At 32%, the Netherlands has relatively fewer people working in large enterprises compared to the EU average of 40% and especially Germany at 52% (Eurostat).

Innovation:

- On rankings reflecting the innovative capacity, the Netherlands subsequently also scores high: 6th on the Innovation Union Scoreboard 2014 and 4th on the 2013 INSEAD Global Innovation Index.
- The Innovation Union Scoreboard 2014 shows that R&D expenditure in the business sector as a percentage of GDP is 1.2 in 2012 in the Netherlands, compared to 1.3 in the EU, 1.5 in Belgium and 2.0 in Germany. Finland leads the scoreboard with an R&D intensity of 2.4% of GDP, twice the value in the Netherlands.
- Problematic in the Netherlands is access to funds for innovation. Figures from Innovation Union Scoreboard on availability of Venture Capital as a percentage of GDP show a score just above the EU average, which is even low compared to the U.S., for example.

R&D expenditure:

- In 2010, R&D expenditure in the Netherlands was approximately €5 billion, which is 1% of GDP. Around 75% of the expenditures originated in the top sectors Agro-Food, Chemicals, HTSM and Logistics (CBS topsectorenmonitor 2010).

Annex:

List of subsectors that correspond to Manufacturing as used in factsheet on page xxx
C10 - Manufacture of food products
C11 - Manufacture of beverages
C12 - Manufacture of tobacco products
C13 - Manufacture of textiles
C14 - Manufacture of wearing apparel
C15 - Manufacture of leather and related products
C16 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17 - Manufacture of paper and paper products
C18 - Printing and reproduction of recorded media
C19 - Manufacture of coke and refined petroleum products
C20 - Manufacture of chemicals and chemical products
C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22 - Manufacture of rubber and plastic products
C23 - Manufacture of other non-metallic mineral products
C24 - Manufacture of basic metals
C25 - Manufacture of fabricated metal products, except machinery and equipment
C26 - Manufacture of computer, electronic and optical products
C27 - Manufacture of electrical equipment
C28 - Manufacture of machinery and equipment n.e.c.
C29 - Manufacture of motor vehicles, trailers and semi-trailers
C30 - Manufacture of other transport equipment
C31 - Manufacture of furniture
C32 - Other manufacturing
C33 - Repair and installation of machinery and equipment

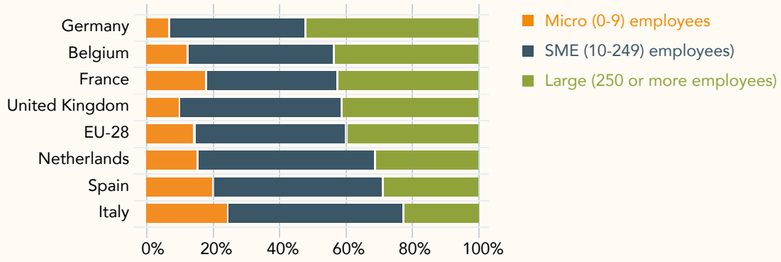


FIGURE 2

Relative shares of enterprise types in manufacturing based on number of persons employed
Source: TNO based on Eurostat

STATE OF PLAY

4

So now, after providing a quick overview of what Smart Industry is and how it can affect the Dutch industry and society, the question is: How does the Netherlands address Smart Industry? How flexible are we to adapt to future changes - or even to those close at hand? The following sections provide a brief outline of activities in our industry, knowledge infrastructure and government, supplemented with a glimpse of what some other countries are doing in this area, with the ultimate aim of drawing conclusions on where our strengths lie and where we should improve to become fit for the future.

The findings in this chapter focus on the Dutch High Tech Systems and Materials Industry. Additional aspects in other industries are highlighted in separate sections.

4.1 A SMART HIGH TECH INDUSTRY

Products
The Dutch industry competes on the basis of smart and integrated products of high quality. Within the HTSM sector, OEMs like ASML, Philips, Océ and FEI mainly excel because they succeed in creating added value through developing integrative products that meet customer needs. Dutch component suppliers compete on specialist knowledge and technology. Examples are companies such as Fokker (see box page 48) and ten Cate, which excel in thermoplastic composites, and VDL ETG, Frencken Europe, NTS-Group, KMWE and Demcon who operate as high mix, low volume, jigh complexitysuppliers to OEMs. These companies often closely connect to German industry as preferred suppliers, usually in niche markets.
The nature of the products, components and equipment produced in the Netherlands provides an excellent position to address the challenges in applying ‘smart’ to the production process.

State-of-the-art technology
Additionally, Dutch industry benefits from an excellent knowledge position. Data processing is key to the competitive advantage of Philips medical, translating sensor data into images. ASML excels in bringing sensors together so you can produce micro-scopic parts and position them with high accuracy. And Océ surpasses the competition in system engineering by making use of, for example, material properties in production equipment development. The state-of-the-art technology available in the Netherlands is of paramount importance to Smart Industry. However, challenges are expected in the implementation of the far-reaching changes that are needed to facilitate the crossover from ICT to physical equipment. Especially since awareness in the ICT industry of the Smart Industry development seems low, and the mutual understanding between the ICT and manufacturing industries is insufficient for a smooth transition.

Culture
Favourable cultural aspects make the Dutch industry competitive and a reliable international partner. Smooth and open collaboration between different disciplines is in the DNA of Dutch industry. The qualities of Dutch industry in system integration and conceptual innovation receive international acclaim. This is reinforced by a work ethic in which Dutch employees do not just carry out what is asked but think critically and contribute with suggestions for improvement. These virtues of Dutch industry will be key in the transition to Smart Industry, to address the opportunities of larger markets in a smaller world, where company strengths become more important. However, companies report a lack of entrepreneurial

skills and sufficiently qualified (adaptive and creative) labour, which presents a serious challenge to the transition to a Smart Industry strategy.

Activities
Current industry activities already closely align with the Smart Industry initiative. Companies feel the sense of urgency to change and are actively implementing 'smart' manufacturing technologies to retain their competitive advantage. Strategies employed here are smart automation (see box PM group page 34), integrated planning within the value network (see box Matador page 28 / Brainport Industries page 27), modular product design approaches and smart use of manual labour (see box Lely page 19 / Marel page 38), since humans remain a highly flexible component of the production process. Nonetheless, it is uncertain whether the current strategies deployed will provide the industry with the innovation it needs to adapt to the Smart Industry developments. Adapting to these disruptive changes in industry often demand high-risk investments. Here lies a challenge as these funds - mainly as a result of our global economic status - are not easily accessible.
Comparable strengths and challenges are apparent in other industries:

Chemical Industries
In the chemical industry, the increased demand for functional materials with client-specific requirements leads away from the current focus on bulk production. Through 'computational technologies', manufacturers can make a computer model of the needed chemical properties, which are then sent to the factory. The deployment of micro-reactors is a possibility for increasing flexibility in production since part of the production capacity can be phased out, instead of switching the whole production on and off. Because of the stringent safety requirements, the chemical industry is set on reducing the number of people on site, ultimately resulting in 'lights-out' production facilities. Furthermore, the implementation of Smart Industries in other sectors

SITECH SERVICES

Supplier of manufacturing services in the process industry
World Class Maintenance Champion Rob de Heus

Within Sitech, we see good opportunities for the process industry in the Netherlands. However, this requires a great deal of creativity and innovation within this sector. Only "world-class" companies that offer demonstrable added value will survive – innovation and top-performance are key issues.

It is necessary that the importance of the process industry is recognised and supported by the government. It is important for the process industry that the preconditions for being competitive are created. On the one hand, this has to do with circumstances beyond the direct control of the industry. Something must be done about the current energy prices in Europe. On the other hand, it has to do with internal process implementation. Because of the greatly increased competition from outside Europe and the aging of existing assets, European companies are forced into far-reaching process intensification. That is to say, achieving the highest production volumes at the lowest cost per tonne of product through automation with very high availability.
For the lowest Total Cost of Ownership, installations must be low-maintenance and independent of people. This can be done by utilising state-of-the-art process technology, process control, high-quality predictive "condition monitoring" techniques and highly integrated IT maintenance techniques.
To achieve longer operating times and less downtime for inspections, comprehensive databases (Big Data) are required to analyse performance and adjust deviations. All this demands that our employees learn to work with these new techniques and technologies and significantly enrich their level of knowledge.

What applies to our company goes for the entire process industry in the Netherlands. We must all learn to deal with these innovations. Without collaboration in this area within the corporate world of the Netherlands, there cannot be a healthy future for our company or for the Dutch process industry.

PHILIPS CONSUMER LIFESTYLE

OEM of Consumer Products
Site Manager Philips Drachten Rob Karsmakers

Philips Consumer Lifestyle Drachten is the largest development and industrial site of Philips Consumer Lifestyle, one of the three sectors of Philips. It employs 2,000 people of 35 different nationalities. Electric shavers have been designed as well as produced for over 60 years. The site develops many other innovative products, such as beard and hair trimmers, lady shavers, vacuum cleaners, coffee makers, hair dryers and wake-up lights. Many Consumer Lifestyle products that Philips markets worldwide contain technical innovations that originated in the Philips Drachten design centre.

Philips Drachten is characterised by a co-location of technology, product and process development, industrialisation and mass production. The foundation for remaining competitive as an innovative industrial site on a global scale is the ongoing design of innovative and customer-focused propositions. This requires a global mindset and conceptual innovations that provide actual added value to customers - innovations in product and process architecture as well as innovations in the manufacturing industry.

Production has strong industrial process characteristics, such as high initial investment, a high degree of automation and true professionalism on the shop floor. Modern production that is based on clever concepts and that uses the latest methods that allow rapid feedback and "zero defects", focusing on "Lean" and assisted by the "economy of scale" makes the industrial operation in Drachten competitive across the globe.

creates opportunities in the chemical industry by, for example, recycling in a circular economy and new materials for 3D printing. However, the large, long-term investments and high cost of phasing out old production make change difficult in the chemical sector. Micro-reactors are only marginally deployed and factories in Germany and the United Kingdom are ahead in computational technologies.

Logistics
The logistics industry explicitly faces the challenge to not only improve its own smartness, but also to adapt to the smartness of other sectors. High consumer demands, with shorter time to market and service-oriented products, make logistics an essential part in the value network and require considerable flexibility. Smart Industry can have a huge impact on the transport and logistics sector. Flexibility and speed will be essential in the future. It's possible that, in the future, control systems could operate based on decentralised autonomous decision-making. In logistics there is a focus on the facilitation of the increased interaction between different partners in the value chain by supplying information technology and deploying concepts like iCargo and iWharehousing. New technologies like RFID are key enablers for these game-changing developments. Other promising future technologies are autonomous driving and intelligent infrastructure. A challenge will be to adapt decentralised decision-making to logistics systems.

Agro-food
In Agro-food, more scientific agriculture leads to more sensors, robots and drones in fields, dairy farms (see Smart Dairy Farming, page 50-51) and greenhouses in order to optimise the combination of crops and conditions. Furthermore, producers of consumer foods are developing tailor-made food for the individualised fulfilment of nutritional needs and envision the future use of food as replacement medication. Agro-food could benefit more from utilising technologies developed in other domains.

4.2 SMART INDUSTRY AND RESEARCH

- Embedded Systems Innovation by TNO (TNO-ESI) collaborates in an open innovation structure with a wide range of industrial and academic partners, in R&D in embedded systems technology.
- Innovation Zuid is a partnership between developing companies and the Chamber of Commerce for composing road maps for collaborative development on High Tech systems and Materials.
- Holst Centre is an independent open-innovation R&D centre that develops generic technologies for Wireless Autonomous Sensor Technologies and Flexible Electronics. A key feature of Holst Centre is its partnership model with industry and academia based on shared road maps and programmes.
- Innovative Dinalog collaborative projects, such as "Proactive Service Logistics" (Proselo) and "Maintenance and Service for Maritime Logistics Assets", aim to optimise logistics over different value chains in a so-called cross-chain control tower.

The broadness and relatively high average quality of the Dutch knowledge infrastructure will be instrumental in developing a Smart Industry. Dutch companies, universities and research institutes are world leaders in (aspects of) System Engineering, Mechatronics, Electronics, Nanotech, Sensor Technology (optics, radar, electromagnetism, etc.), ICT and human-machine interaction.

Dutch universities work on an essential solid knowledge base as well as on technical and social elements of Smart Industries. New added value can be expected from collaboration of beta, gamma and alpha sciences. Innovation is increasingly a result of public-private collaboration, not only in research projects like Dinalog (see box Dinalog, page 50-51) but also in open R&D centres like Holst Centre. But there is room for improvement.

Although knowledge in the different domains relevant to Smart Industries is world class, additional efforts are needed to combine the state-of-the-art in these domains in order to create integrated solutions that enable the Smart Industries concept.
A concern in the Netherlands is the current lack of valorisation and capitalisation of this knowledge into economic growth, the so-called innovation paradox. Increasing the ease with which companies can access

GORDIAN LOGISTIC EXPERTS

Supplier of logistics services
Director Jürgen Donders

As a logistics management consulting firm, we see that Dutch companies are constantly trying to enhance logistics performance and reduce operational costs and working capital. Up to now, this has mainly occurred within the walls of the company. In contrast, the control tower concept tries to find solutions in the chain.

With a Control Tower, we make an entire chain of businesses more competitive by gathering information from the whole chain and using it to optimise collaboration between all parties. However, a Control Tower is more than an ICT solution; it is actually about a different business model with ICT and smart algorithms as powerful enablers.
A case in point is the development and implementation of a Control Tower for the remote control of stocks of spare parts in service and maintenance processes. Applications at, for example, the Royal Navy, NedTrain and Marel have generated millions of euros in savings. The savings are primarily the result of smart & shared resources that optimally control stocks from the control tower based on transparency in the chain and using the most appropriate algorithm.

In innovative Dinalog collaborative projects such as "Proactive Service logistics" (Proselo) and "Maintenance and Service logistics for Maritime Assets" (Maselma), there is optimisation across various chains in a so-called cross-chain control towers. In these projects, we try to organise the supply chains in such a way (proactively) as to prevent failure, without increasing stock and other costs.
The Netherlands is currently an international leader in the development of these innovative concepts and their practical implementation. The purpose of these projects is, therefore, to develop value propositions that we can broadly place in the international market.

knowledge developed at knowledge institutes and joint knowledge development and knowledge circulation should be central in a Smart Industry initiative.

The Netherlands could build on the experiences in several regional initiatives that were relatively successful in the valorisation of knowledge.

For example, the Eindhoven region is home to world players in the manufacturing industry such as ASML and Philips, who invest heavily in R&D. The High Tech Campus, Eindhoven University of Technology and TNO provide a large and broad knowledge base, outstanding in, for example, 3D printing and embedded systems. Finally, the Dutch Design

FOKKER AEROSTRUCTURES

Supplier of aircraft components

Director of Industrialization Marc van Herpt

Fokker Aerostructures designs and manufactures aircraft components. Fokker does not usually design the form and aerodynamics of the aircraft component, but the construction and building method thereof. This means that we need to distinguish ourselves from our competitors in functionality of the materials used (weight, durability, strength) and the cost of our products.

In recent years, Fokker has invested in key innovations in both materials (such as our unique GLARE solutions and fibre-reinforced thermoplastic) and production methods (e.g. Single Step Assembly and induction welding of thermoplastic). With these solutions, we have built up a good position with, amongst others, the Airbus A380 and corporate jets.
Fokker's next step is the breakthrough of these technologies into a high-volume programme with Airbus A320 or the Boeing 737, for which it is essential that we drastically reduce production costs.

To make this possible, our factories will look significantly different in the future: further production automation, flow production, smart logistics solutions, flexible moulds ("smart tooling") and broader deployability of production staff. We will collaborate with (Dutch) companies and institutions with knowledge and experience in the area of robots and complex production logistics.

The good news is that we are dealing with a huge growth market. Recent figures from the French government suggest that the aerospace composites market will grow from 7.0 to 14.5 billion euro in the 2014-2020 period! But there are threats on the horizon: there is increasing competition from countries such as India and China, with whom we cannot compete on (wage) costs. Innovation and optimisation are key words if we want to remain part of this market. So there is a huge challenge for our industry in general and for Fokker in particular.
Together with the government, our supply chain and the many high-quality knowledge institutions in the Netherlands, we seize this challenge with both hands!

Academy and specific academic tracks at Eindhoven University of Technology (e.g. Human Technology Interaction) provide a dedicated focus on the non-technological aspects that coincide with the development of a Smart Industry. Similar ecosystems exist around nanotechnology in the east of the Netherlands, instrumentation in the west (see box Holland instrumentation, page 50-51) and agriculture in central Netherlands.

4.3 SMART INDUSTRY AND GOVERNMENT

National policy

The newfound confidence in innovation policy of recent years has led to an alignment of innovation programmes, support activities from governmental agencies and financial and tax instruments. This provides fertile ground for a transition towards a Smart Industry.

Relevant HTSM road maps:

- Embedded-systems,
- Mechatronics and manufacturing,
- High-tech Materials,
- Nanotechnology and
- ICT*

** The ICT road map is part of the HTSM top sector but was initiated to stress the role of ICT technology in enabling all other sectors.*

The top-sector programme is one of the two pillars of the Dutch industrial policy, focusing activities in nine industry sectors. The top sector of High Tech Systems and Materials (HTSM) is closely related to Smart Industry. For example, the road-map-embedded systems develop integrated hardware/software systems built into systems and devices.

Similar supporting activities for Smart Industry are found in other top sectors like agro-food, chemicals and logistics. For instance, the logistics top sector involves all the knowledge needed to plan, organise, implement and control the goods and information flows from raw materials to finished product. Other examples of governmental activities supporting Smart Industries focus on ICT, labour and seed investment. 'ICT breakthrough projects' promote the use of ICT to increase competiveness of companies. The 'Techniekpact' and human capital agenda aim to provide future demand for skilled labour. And the government recently provided extra financial support for early-stage development.

On the other hand, most of these activities have been fragmented until now and lack a common understanding of how to create a Smart Industry in the Netherlands. There seem to be opportunities to align road maps within the top sectors, for example within the HTSM top sector, to Smart Industry ambitions. Similarly, there is an opportunity to align activities between the top sectors of HTSM, Chemicals and Agro-food based, for instance, on the coinciding theme of ICT. Furthermore, an additional focus on production process development instead of the current focus on product development in most of the road maps within HTSM, Chemicals and Agrifood would advance Smart Industry development. Companies also indicate that substantial funds to support developments are currently unavailable. Finally, there is no specific programme for services and most top sector road maps do not focus on services.

Regional policy

Smart Industries are supported by regional governmental activities. The manufacturing regions of Noord-Brabant, Limburg, Gelderland, Overijssel, and the north of the Netherlands have all recently created significant funds (100+ million euros per

ILLUSTRATIVE PROJECTS

ROADMAP 3D PRINTING

Spearheaded by BOM, LIOF, EIZ and the Chamber of Commerce

The digitisation of society has facilitated a new "industrial printing" playing field. Players and application areas range from educational and knowledge institutions, the medical community and the arts and culture sector to small and large companies in the high-tech and automotive sectors. New applications with metal, ceramic or organic materials require a great deal of experimentation, creativity, material, process and equipment knowledge, and perseverance in order to be put into operation. This road map homes in on 3D printing, or Additive Manufacturing Technology.

HOLLAND INSTRUMENTATION

Spearheaded by instrumentation companies, TNO and Innovation Quarter

The West of the Netherlands has a very strong instrumentation industry, built around various universities and knowledge institutions. This instrumentation industry makes instruments for advanced satellites, innovative medical instruments, and measurement and control systems for the processing industry, laboratories and shipbuilding. The individual companies belong to the world top within their niche and constantly innovate to remain there.

INTEGRATED MAINTENANCE AND SERVICE LOGISTIC CONCEPTS FOR MARITIME ASSET (MASELMA)

Spearheaded by Dinalog, industrial companies and knowledge institutions

In the maritime sector, service logistics support and maintenance of systems constitute a significant fraction of the operating costs. It is expected that the project results will enable a significant reduction of the total cost of ownership for asset owners and provide the OEMs / system integrators and service providers with opportunities for new business. At the same time, from a scientific perspective, the innovative approach to integrating the fields of maintenance, service logistics and supply chain cooperation is expected to have a large impact.

COORDINATED ADVANCED MAINTENANCE & LOGISTICS PLANNING FOR THE PROCESS INDUSTRY

Spearheaded by DI-WCM, companies from the processing industry and knowledge institutions

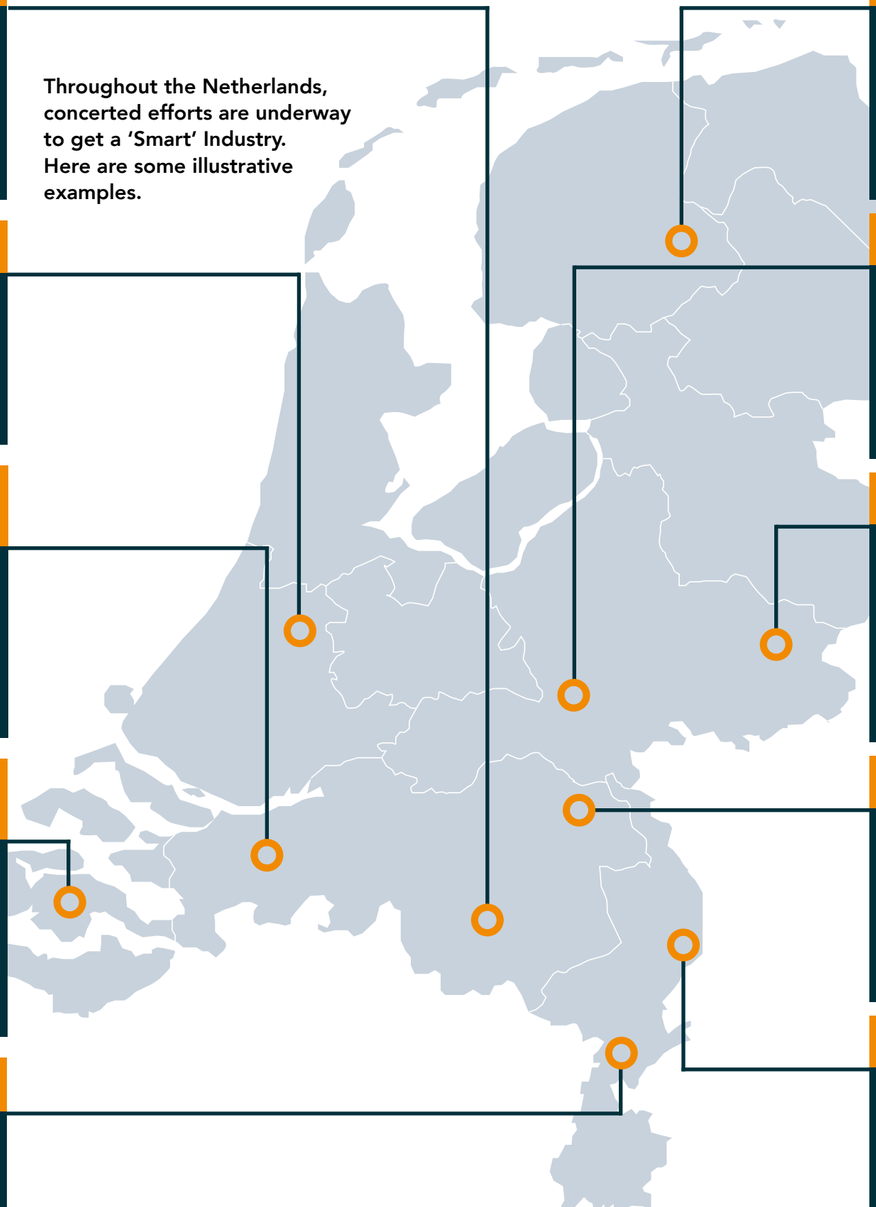
Planning condition-driven maintenance requires historical data. If a machine stops or a sensor detects a problem, the entire process of scheduling the right mechanic or arranging the parts and tools has yet to get underway. That is not efficient. Collecting the proper data is not simple. With one company, there is relatively little data on which to base a decision. Collaboration between companies can yield more data and, therefore, more relevant information.

LIMBURG MAKERS

Spearheaded by LIOF, the Province of Limburg and the Chamber of Commerce

Limburg SMEs operating in the manufacturing industry receive additional support. Through Limburg Makers, the SME manufacturing industry is offered a comprehensive incentive and support programme with which it can develop further and continue to improve its competitiveness. Limburg Makers also encourages collaboration between SMEs themselves and between SMEs on the one hand and educational and research institutions on the other hand.

Throughout the Netherlands, concerted efforts are underway to get a 'Smart' Industry. Here are some illustrative examples.



REGION OF SMART FACTORIES

Spearheaded by the NOM, knowledge institutions and high tech companies

An extensive network of companies and knowledge institutions in the North of the Netherlands has taken the initiative to develop new techniques in the coming years that can significantly improve productivity of the manufacturing industry. The group, which calls itself "Region of Smart Factories" (RoSF), consists of large multinationals such as Fokker and Philips and many regional SMEs, knowledge institutions including SRON and ASTRON & IBM Center for Exascale Technology, the University of Groningen and the three northern universities of applied sciences.

SMART DAIRY FARMING

Spearheaded by companies from the dairy industry and knowledge institutions

Within the SmartDairyFarming project, companies, knowledge institutions and dairy farmers work together on the development of innovative resources in the fields of animal health, fertility and nutrition. The concrete result consists of sensors, indicators, decision models and advisory products that help in making the right choices in the care of cows. Proper care contributes to better health and higher life expectancy of the animals. As such, this project contributes to the sustainability of the chain.

SMART BENDING FACTORY

Spearheaded by 247 tailor steel and metal processing companies in collaboration with Oost NV

The industry demand in 2014 is based on speed and accuracy of information, very short lead times, on-demand delivery with guaranteed delivery times, all at competitive prices. In the Smart Bending Factory project, 20 non-competitive OEMs in the metalworking and processing industry are brought together in a community environment in order to share knowledge, experience, information and resources, and to run non-strategic machining processes jointly in order to maintain or improve their competitive position.

PRODUCT LIFECYCLE MANAGEMENT IN THE VALUE CHAIN

Spearheaded by 85 high-tech suppliers in Brainport Industries

The Brainport Industries cooperative, which comprises 85 1st, 2nd and 3rd tier suppliers, is an initiative working to create a future-proof manufacturing industry. They all share the view that competition occurs more and more between chains rather than between individual companies. One of the projects within Brainport Industries is Product Lifecycle Management (PLM). PLM's goal is to align all life-cycle processes optimally and to thereby optimise the net proceeds of the product throughout its life cycle.

FLORA FLUIDS

Initiated by NEVAT, agro-food companies and knowledge institutes

NEVAT is an network of 200 ambitious suppliers across sectors like high-tech, automotive and agro-food. One of the chain optimalisation projects within NEVAT is "Flora Fluids". Here a Plant Robot is developed for extracting useful fluids from plants in a more productive way. Unique in this project is the sharing of technology and market intelligence between innovative SME's, knowledge institutes and financials, to speed up the time to market . Partners in this project are: DCD, Wetering, LIOF, Holland Innovative, Rabobank Venlo, TU Delft, Feed Innovation Services, and the HAS Hogeschool.

region) for innovation in their industry. Over the past years, we have seen regions position and brand themselves into specialty positions in order to maintain or acquire a competitive target in globalising markets (see Limburg Makers / Region Smart Factories, page 50-51).

Whereas regional activities are characterised by a strong focus, from a national perspective these activities have a diverse character both in the type of support they offer (e.g. accommodation support or market entry support) and in their focus (e.g. renewable energy, food, instrumentation, manufacturing, high-tech industry, nano-technology, smart factories etc.).

Elements of Smart initiatives are already addressed in top-sector programmes and regional activities, providing the possibility for the initiative to 'hit the ground running'. Similarly, Smart Industry could provide a common focus for relevant parts of the top-sector programme and regional activities that would allow the sum to be more than its parts. Finally, industries demand stable governmental policy.

Within the framework of EU policy, regions will determine their Smart specialisation in the coming years in order to be able to allocate structural cohesion funds partly made possible by the EU. It is of vital importance that a Smart Industry specialisation is defined at the regional level. In that strategy, a region can opt to invest in different programmes to promote, develop and accelerate certain kinds of industries. And since Smart Industries will lead to more regional networks, selecting a Smart specialisation strategy will support this development to "re-shore" industries. With the faster response to changing market requirements, production series will shrink and businesses will seek to avoid long-distance transport and opt more for local, regional suppliers. Just as in Porter's Competitive Advantages of Nations/Regions, this trend will reinforce successful regions and different regions will demonstrate different strengths.

4.4 SMART INDUSTRY INTERNATIONAL

Many countries are developing programmes focused on Smart industries, including all of our main trading partners. Apart from the countries shown in the table, initiatives have been identified in the United Kingdom, France and some Asian countries like Korea and China. In general, these initiatives receive considerable governmental support.

Although the Netherlands is developing multiple initiatives nationally and regionally on aspects of Smart Industries, it is understood that the industry would benefit from an integrated national approach. In this approach, the Netherlands should benefit from the activities undertaken at European level and, given the warm relations between Dutch and German industry, closely collaborate with the German Industry 4.0 initiative. It is of great importance to be involved in the German standardisation activities to ensure seamless integration between Dutch suppliers of components and equipment and German industry.

Compared to other countries, the Netherlands could distinguish itself by focusing on Smart Industry aspects that closely align with the Dutch industry strength in system integration. That is to say, a network-centric approach in which we combine our systemic strength and open collaborative culture enabled by Cyber Physical Systems and new manufacturing technologies. This could boost the development of new ways of flexible production and customisation that should be internationally hard to beat.

	Duitsland	België	Denemarken	Verenigde Staten	Europese Unie
Programme name	Plattform INDUSTRIE 4.0	MADE DIFFERENT	MADE	SMLC National Network for Manufacturing Innovation (NNMI)	EFFRA a MANUFUTURE initiative
Goal	To prepare the German industry for the next industrial revolution	Make factories future-proof	Stimulate innovation	Promote 'American-made' and retain jobs	Reverse the declining role of industry in Europe
Demarcation	Cyber physical systems	Technological, business model and social innovation	Rapid product & production development, model-based production & complexity nagement	Advanced Production	
Priorities	• Horizontal and vertical system integration • Normalisation and standardisation • Logistics • Labour and organisation	• World-class production technologies • Simultaneous product and production development • Digital factory • Human-centred • Networked factory • Eco-production • Smart production	• High speed product development • Modular production platform for rapid deployment of production • 3D printing and new production processes • Model-based knowledge sharing in global supply chains • Proactive value chains • Lifelong product customisation via an ICT service architecture • Future production paradigm • Hyper Flexible Automation • Sensors and quality control	• Additive manufacturing • Digital manufacturing & design • Lightweight and modern metals • Next generation power electronics	• Advanced manufacturing processes • Adaptive and smart manufacturing systems • Digital, virtual and resource-efficient factories • Collaborative and mobile enterprises • Human-centric Manufacturing • Customer-focused manufacturing
Method	High-level advisory board Industry 4.0 with industry leaders and thematic PPS consortia	Research programmes in public-private partnerships	Grants for initiatives and platforms for knowledge sharing	Establishment of national research centres	Research programmes in public-private partnerships in FP7, Horizon 2020 and the KETs programme
Substance (of which gov.)	200 million euros	8,4 million euros	24 million euros	700 million euros	1.200 million (600 million) euros
Remarks	Critics posit that the German Industry 4.0 programme leans too heavily on technology push. The programme aims to take a leap forward and therefore is distinctively future-oriented			The national programme is organised as an 'umbrella initiative' under which a large number of initiatives are brought together, leading to disparate focus	Besides the FoF programme, ICT programmes are also relevant

INTERMEZZO

OPPORTUNITIES	THREATS
Smart Industry will enable leading competitive Dutch industry sectors like High Tech, Chemicals, Logistics and Agrofood to increase participation in Asian and other global industries, taking over some markets due to more flexibility and high-quality production.	Misalignment with (standardising) activities in other countries will reduce the opportunity for collaboration with international value chains.
The IT service industry in the Netherlands is strong and plays a crucial role in establishing Smart Industry, which provides new opportunities for the IT sector to export these new innovative capacities to other countries.	Retail and wholesale sectors can expect a diminishing position and need to anticipate forward integration of value chain activities. New business models need to be developed.
Dutch industry is well known for design and innovation, and it is becoming increasingly important because flexible manufacturing can provide tailor made production.	Information is key but is susceptible to theft, misuse or even disruption of production. Hacking and other forms of misuse must be anticipated by securing networks and developing legal approaches, protocols, etc.
For the machine and instrumentation industry, the technologies and services needed for Smart Industry is a challenging new market.	The present shortage of high-skilled technical labour could be pivotal to the successful implementation of Smart Industry.
As Dutch industry is highly international, we have an advantage in connecting to other initiatives in other countries. The Netherlands should benefit from the activities undertaken at European level and, for example, closely cooperate with the German Industry 4.0 initiative.	Young entrepreneurs and SMEs are vital for this development. Improving support from government policy and larger enterprises is pivotal in order to benefit optimally from the opportunities.
New initiatives will emerge for small and medium enterprises. This is an opportunity for bottom-up development of new businesses and companies.	Standardisation of communication internationally could lead to fewer barriers to entry of international competitors into our value chains. This could lead to increasing competition and increasing international participation in our economy.
Our strong service economy provides the opportunity to further develop the accompanying services that will create the new high added value business.	Smart Industry and its accompanying services can lead to increasing internationalisation of services. Firms in other countries can take over the services from Dutch firms, especially in the case of major players like IBM, Amazon and Google.
The open and non-hierarchical business culture also provides opportunities to further develop the network centric way of production.	

STRENGHTS	WEAKNESSES
Industry	
The nature of the products, components and equipment produced in the Netherlands provides an excellent position to address the challenges in applying 'smart' to the production process.	Awareness in the ICT industry of Smart Industry development seems low and the mutual understanding between the ICT and manufacturing industries is insufficient.
Favourable cultural aspects (multidisciplinary cooperation, conceptual innovation) make the Dutch industry competitive and a reliable international partner.	Companies report a lack of entrepreneurial skills and sufficiently qualified (adaptive and creative) labour.
Companies feel the sense of urgency to change and are actively implementing 'smart' manufacturing technologies to retain their competitive advantage.	High-risk investments needed for disruptive changes in industry are not easily accessible.
Research	
The broad and relatively high-quality knowledge infrastructure is a world leader in System Engineering, Mechatronics, Electronics, Nanotech, Sensor Technology, ICT and human machine interaction.	Although knowledge on the different domains relevant to Smart Industries is world class, additional efforts are needed to combine the state-of-the-art in these domains to create integrated solutions.
The Netherlands could capitalise on the practical experiences in several regional initiatives that are relatively successful in valorisation of knowledge.	Increased access to knowledge developed in knowledge institutes and joint knowledge development addresses the current lack of valorisation and capitalisation of knowledge.
Government	
The recent alignment of governmental instruments and existing focus on elements of Smart Industries provide the possibility to 'hit the ground running'.	There seem to be opportunities to align activities between the top sectors and road maps within the top sectors towards an integrated Smart Industry strategy, focusing on production processes instead of products.
Smart Industries are strongly supported by regional governmental activities.	Whereas regional activities are characterised by a strong focus, these activities have a diverse character from a national perspective.
Regions have branded themselves into specialty positions in order to maintain or acquire a competitive edge in globalising markets.	
International	
Compared to other countries, the Netherlands could distinguish itself by focusing on Smart Industry aspects that closely align with the Dutch industry strength in system integration.	A broad selection of countries is developing programs with considerable governmental support, which focus on smart industries, including all of our main trading partners.

Compared to other countries, the Netherlands could distinguish itself by focusing on Smart Industry aspects that closely align with Dutch industry strengths in system integration. That is to say, a network-centric approach in which we combine our systemic strength and open cooperative culture enabled by Cyber Physical Systems and new manufacturing technologies. This could boost the development of new ways of flexible production and customisation and contribute to a strong international position of Dutch Industry.

OUTLINE SMART INDUSTRY AGENDA

5

5.1 INTRODUCTION

The study carried out shows that the developments, which we refer to as “Smart Industry”, are of great importance to the Dutch economy. It also appears that Dutch companies are already actively working on this. However more is possible and needed to profit from all opportunities and in order to respond satisfactorily to challenges. This is not “business as usual”; the impact is too great and the pace of changes is too high for that. The complexity, cohesion and diversity of effects and measures call for intensive collaboration over the coming years in the golden triangle of companies, educational & knowledge institutions and government & intermediary organisations. Based on this study, this chapter sketches the outlines of a joint Smart Industry Agenda.

5.2 STRATEGIC OBJECTIVES

The starting point of the Smart Industry Agenda are strategic objectives.
A strong internationally operating industry is conducive to prosperity and well-being in the Netherlands. Given the strength of the current (manufacturing) industry, the Dutch culture of collaboration and the knowledge level, there is every reason to work on a strong and future-proof industrial basis for the Netherlands.
At the same time, this study shows that there is a major challenge to adapt new emerging ICT, data and production technologies because these allow demonstrable disruptive changes to production and value chains. Moreover, this development will also have a significant impact in domestic sectors, such as retail and wholesale. These changes will have new products, services and business models as an outcome, with the traditional distinction between services and industry gradually fading. A synergetic approach between the ICT domain and the industry sectors like Hightech, Chemicals, logistics and Agrofood is needed.

The two main objectives of the Smart Industry Agenda can be elaborated as follows:

- Strengthening the Dutch industry by making maximum use of the latest information and product technology developments so that it can “produce” (in the broadest sense of the word) more efficiently, more flexibly, higher quality and “tailor made”: Network Centric Production.
- Accelerating the development and co-creation of new business (models), products, services and production technology based on Smart Industry perspectives – by industry in general and also by new companies or companies in sectors that are not traditionally engaged in production (the service sector) and by completely new companies;

To realise the main objectivities, three closely interlinked activities are needed:

- To raise awareness and operational focus with respect to Smart Industry development in the business community, knowledge institutions intermediary organizations and governments;
- Strengthening and linking research, development and business relevant to Smart Industry in the Netherlands;
- Strengthening and linking education and training in the area of Smart Industry and required supporting policy.

The Agenda fits into the corporate/top sector policy and therefore is a deepening of that policy. There are opportunities for connecting road maps within the top sectors on the subject of Smart Industry. In addition, it is also important to make the cross-sector connections between the top sectors.

5.3 TARGET GROUP, TIME HORIZON AND SYNERGY FRAMEWORK

The target group of the Smart Industry Agenda is the business community in general. In this context, this means that the focus will not only be on the frontrunners and High Tech companies, but also on the various companies in the value chain and the supply chain (Medium Tech, Low Tech etc.) and other sectors for which the Smart Industry concept offers new opportunities.
The top sectors of Hightech (including ICT), Chemicals, Agrofood and Logistics were the starting point of this study, but value chains must be more broadly included, with the service sector and the creative industry playing a role.

The time horizon of the activities that form the building blocks of the Agenda will vary:

- Short-term activities. As shown in the previous chapters, for example, there are already successful examples in companies and promising projects. This knowledge and experience can be shared in the short term with a large amount of companies to increase the awareness for this development.
- Medium-term activities. Innovative effort and R&D are needed for more radical innovations in value chains and production processes and process technologies. These efforts can deliver results in the short term, but a longer turnaround time (4 to 6 years) will be required to actually strengthen and link in research and development and business in the area of Smart Industry.

Long-term activities. Apart from some very positive exceptions, basic scientific research in the area of Smart Industry is in its infancy in the Netherlands.
Creating maximum synergy is an important aspect within the framework of the Smart Industry Agenda. This means that the connections between the various disciplines (technical and non-technical), different types of businesses (large, medium, small and new) and various levels of scale (regional, national and European) have to be established.

5.4 FIRST OUTLINES OF ACTIVITIES WITHIN THE SMART INDUSTRY AGENDA

As shown in the previous chapters, there are already many initiatives in the Netherlands that give substance to the agenda. These are partly initiatives at a national level, within the top sectors and the Technology Pact, and partly initiatives that specifically target parts of this agenda such as the Smart Factory initiative from NOM and projects in the context of the European Factory of the Future. The premise of the following description is that the Smart Industry Agenda uses existing activities as a starting point for further reinforcement and acceleration and defines new activities.

5.4.1. New Business with Smart Industry

The first set of activities focuses on accelerating the development and application of new business (models), products and product technology.
It is important to map out the opportunities and challenges of Smart Industry for the current and future business model. These activities focus on OEMs and suppliers, on manufacturers and service providers and/or combinations thereof and other relevant sectors. There is also a great opportunity in this area for new companies and ambitious entrepreneurs, who must therefore also be addressed in this agenda. Building ecosystems between the current industry, relevant R&D priorities, service provision and ICT and new and young companies is important in this respect.
The activities are aimed at faster and better use of knowledge, technology and information concepts that are *already available* and at creating awareness and disseminating knowledge about New Business with Smart Industry. Sector organizations can play a role. A relationship with different forms of financing of innovation will also be established here, in which venture capital will certainly play a role.

5.4.2. New Knowledge with impact for Smart Industry

The second set of activities aim at strengthening and linking research and development and business relevant for Smart Industry in the Netherlands. This involves knowledge development and application. In addition to the development of internationally distinctive R&D priorities, a comprehensive, multi-disciplinary approach is required. The following research areas should be involved:

Technology development and application

- ICT-related technology, including Internet of Things, cloud technology, big data and data processing, embedded systems, cyber-physical systems, RFID, sensors. It concerns not only the hardware, but also the software and “data science”.
- New manufacturing technologies: technology for flexible small series, zero defect manufacturing, additive manufacturing (3D printing), miniaturisation and other “converging technologies” that have a strong influence on this development such as nanotechnology;


Matador

- Interaction is needed within and between the Hightech, Chemical, Agrofood and logistics sectors and beyond (i.e. creative industries).

New business models (data) networks, chain organisation & logistics

- Business models. This focuses on what is perhaps the most difficult part of the agenda to get a grasp on: the development of knowledge about new business models and how they change. Technology, data streams and new services are so dynamic that rapid, large and often unpredictable changes occur.
- Networks / chains: this regards the technological and organisational knowledge needed to allow parties to collaborate within networks and chains. This concerns, amongst others, platform technology, ICT standards, the adaptability of organisations, empowerment and talent management.
- As regards logistics, it is of great importance that this is aligned with the key features of Smart Industry, with speed and flexibility playing a central role. In addition to efficient, increasingly directed transport flows, decentralised systems are also very important in this.

Integrated knowledge

Networks and integration are central concepts in Smart Industry. This means that, in addition to knowledge in (sub)sectors, there is a great need for knowledge and skills that oversee and connect the (sub)sectors. This relates to knowledge of production processes as well as of value chains and networks. The Netherlands boasts a wealth of knowledge and skills in subsectors, such as sensors or 3D printing, but an integrated approach is needed. This integrated knowledge development will also support the synergy framework.

5.4.3. New skills for Smart Industry

The developments described require a great deal from employees, both in terms of content and the manner in which they participate in the organisation. It is therefore about skills and competencies, and it certainly does not only involve staff trained at higher professional education and university level. There is of course already a lot happening in the area of education and life-long learning; consider, for example, the technology pact ("Techniekpact"). Which areas require additional action will have to be investigated. Points to be considered in advance include:

- Training and retraining existing workforce so they acquire the knowledge and skills necessary in the coming years at an appropriate rate;
- Multidisciplinarity;
- Greater demand for process engineers and less for traditional "craftsmen";
- Great demand for ICT professionals and computer scientists, specialising in or linked to, for example, mechanical engineers ("technical ICT professionals").

5.4.4. Supporting policies for Smart Industry

The development of Smart Industry calls for new technology platforms and new forms of standardisation, as well as additional measures and legislation to protect networks or to guarantee privacy. This also requires international alignment and collaboration that will be partly initiated by the business community and that can be supported partly by policy. In this area, collaboration with Germany is obvious. Finally, an excellent ICT infrastructure is very important.

5.5 IMPLEMENTATION

Partners of the Smart Industry Agenda

The Smart Industry Agenda is an agenda for the Netherlands and has to be prepared and (intended) carried out by the business community, knowledge institutions (research and education) and government, i.e. the golden triangle (and especially the relevant top sectors), in close collaboration with intermediary organisations such as trade associations, the Chamber of Commerce and the regional development agencies.
Specifically focusing on companies from sectors such as Hightech, Agrofood, Chemicals, Logistics, Services, ICT engineering firms. It concerns , large companies and SMEs, but young starting companies that develop new business models.

Budget

It will be necessary to ascertain whether existing resources (national, regional government and Horizon 2020) can contribute to making this agenda possible. Whether additional resources are required cannot be determined at this time. The focus now is to first develop the substantive agenda further and, based on this, a decision will be made as to whether additional resources are required and where they should come from.

International embedding

It is very important to link the Dutch agenda with foreign agendas. After all, the core of the agenda constitutes the formation of the networks, which does not follow international borders. Partners in the chain, customers and, increasingly, personnel are located in other countries. As such, international collaboration must be part of the agenda. Matchmaking between Dutch companies and knowledge institutions and foreign parties should also be part of the agenda.

5.6 THE NEXT STEP

As explained in the introduction, this chapter only describes the general outline for an agenda that still needs fleshing out. It is a preview resulting from a preliminary study and an initial consultation with man, most often leading companies and relevant organisations. In addition to valuable suggestions and input, the initiators have also experienced a lot of acclaim and support for the initiative.
Building on this preview and the growing support, the proposal is to begin with the development of the Smart Industry Agenda in the spring of 2014. A broad consultation will be included to come to a widely supported Smart Industry Network for the Netherlands.

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