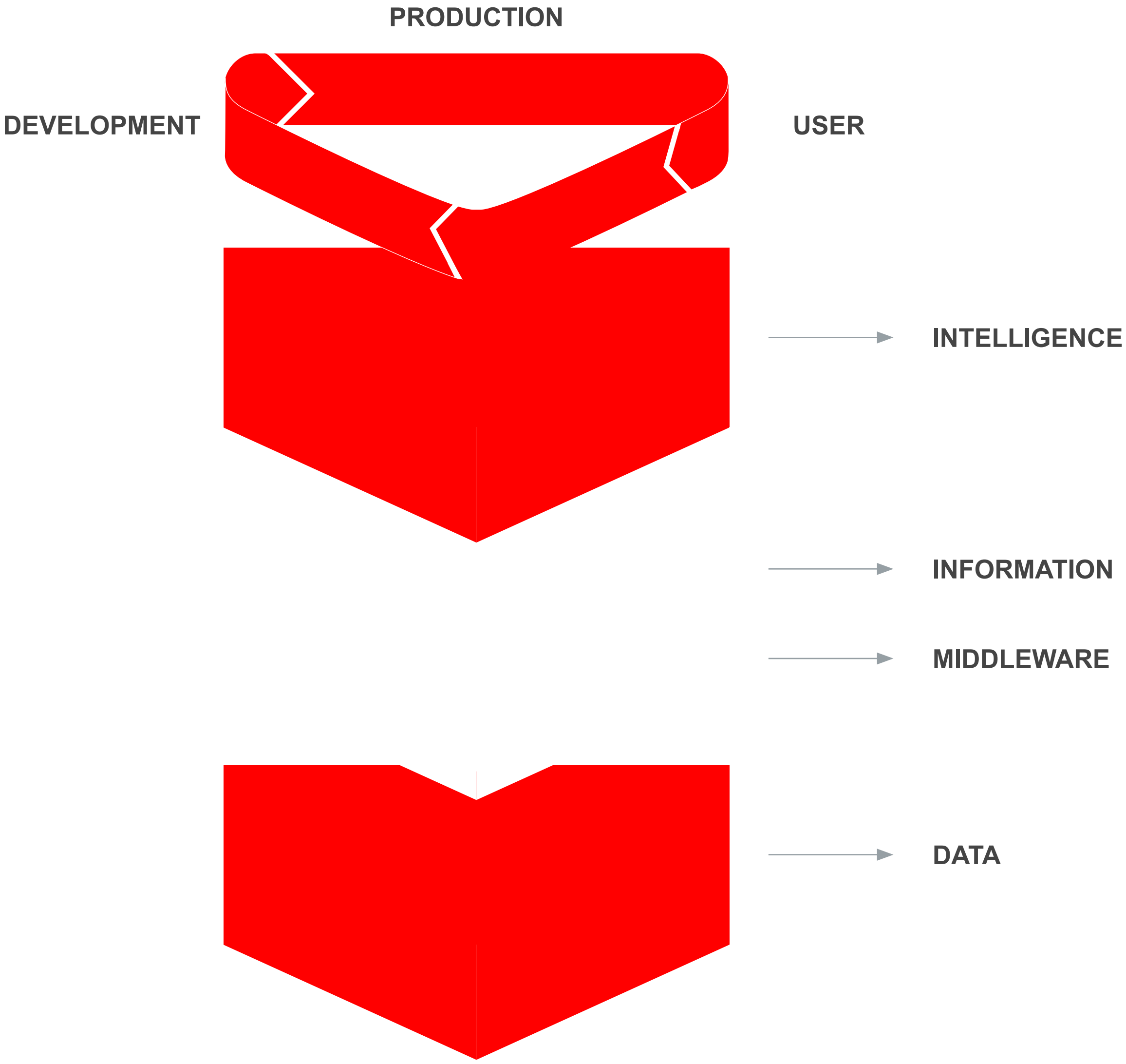
UNIVERSITY OF TWENTE.

FRAUNHOFER INNOVATION PLATFORM
FOR ADVANCED MANUFACTURING

CONNECTED, AGILE MANUFACTURING


PRODUCTION
DEVELOPMENT
USER
INTELLIGENCE
INFORMATION
MIDDLEWARE
DATA

CONTENT

INDUSTRY 4.0

DIGITAL TRANSFORMATION FOR CONNECTED,AGILE MANUFACTURING

What has come to be known as the "Fourth Industrial Revolution" is being shaped predominantly by production digitalisation and networking. Buzzwords such as the "Internet of Things and Services" and "Cyberphysical Production Systems" promise increased networking of autonomous and self-optmising production machines and intelligent products which can be customised to manufacture highly individual outcomes. Much of this remains a vision - for the time being. However, companies with the will to succeed in the fiercely competitive global markets need to consider today the role they wish to play in "Industry 4.0" tomorrow.

In this brochure, we aim to shed a light on often fuzzy topics within Industry 4.0, our understanding of Industry 4.0 and the competencies we, as Fraunhofer Innovation Platform, have to offer to you as our next potential partner in your quest to a "Digital Transformation for Connected, Agile Manufacturing".

For example, we discuss Virtual Dashboards enabling you to make the right decisions, and we discuss what we have to offer you to structure the abundance of data most of the companies face today.

Another new concept that we will address is the Digital Twin, allowing engineers and decision makers to benefit from digitalisation to increase efficiency, effectiveness and quality.

Available technologies today facilitate optimised machine design, uncomplicated commissioning, short changeover times and error-free operation. In addition, we all need to respond to the growing demand for individualized industrial products.

Everybody who wants to launch products and services successfully on today's global markets must learn to exceed own limitations and to shape the process of change, thinking on feet and remaining for ever willing to adapt to the continuously changing requirements.

Start here, start today!

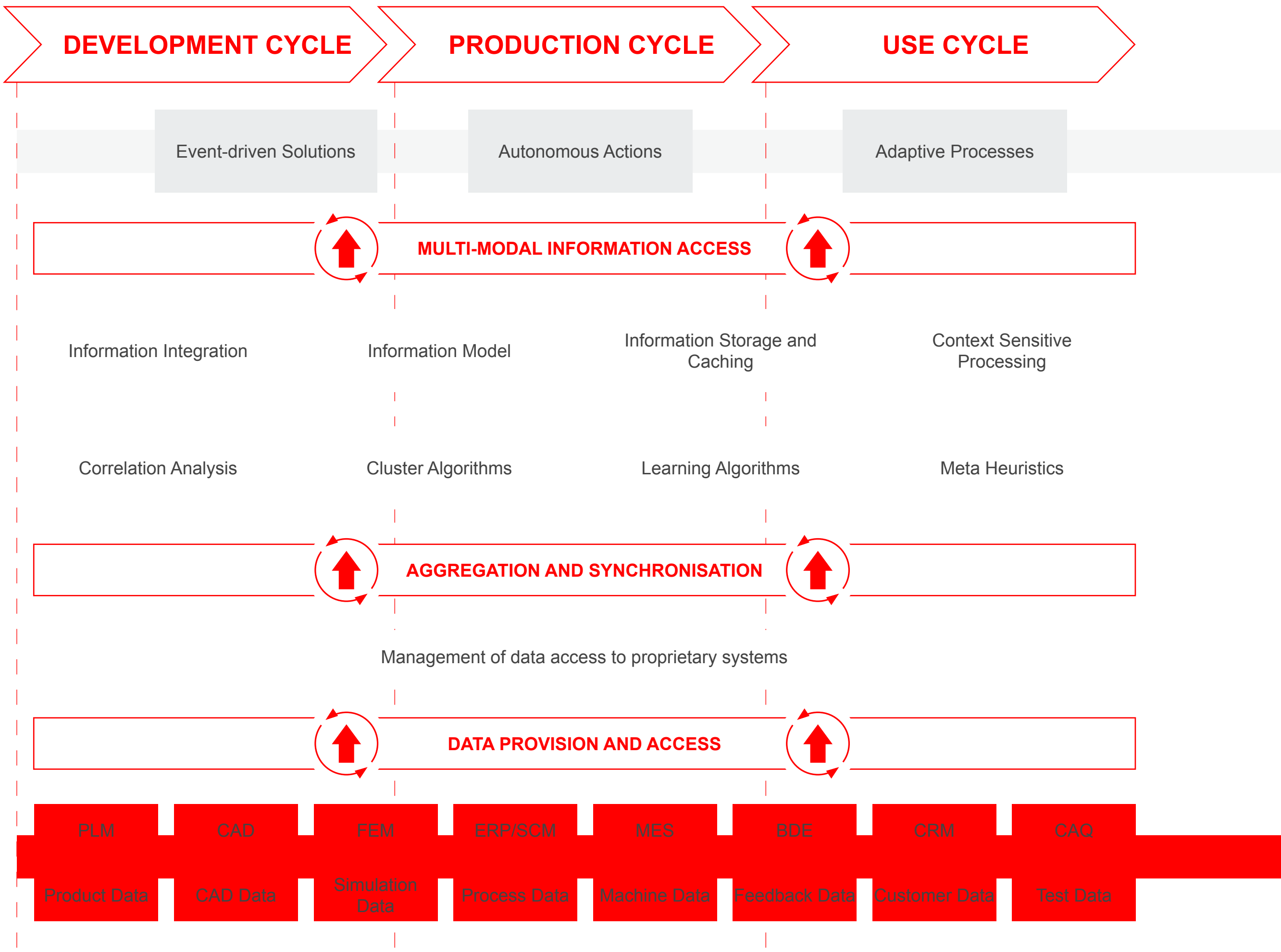
INDUSTRY 4.0

INTRODUCING THE ADVANCED MANUFACTURING LANDSCAPE

Challenges within todays Industry are the optimum usage of the ocean of data, digitalisation, re-configuration of value chains, new environmental regulations, customer centricity and the need for speed amongst many others.

How to deal with the unprecedented pressure to innovate our productions from several fronts at once is in our DNA. Fraunhofer Innovation Platform, either alone or with our cooperation partners, aims to support the Dutch manufacturing companies, of any size or industry, in what we like to refer to as a "Digital Transformation for Connected, Agile Manufacturing". In this context we developed the Advanced Manufacturing Landscape.

The Advanced Manufacturing Landscape describes our perspective on the challenges of Industry 4.0 and focuses on one primary objective: The availability of the right information at any time and any place, throughout the entire life cycle of the product.



Advanced Manufacturing Landscape based on the Internet of Production model developed by WZL of RWTH Aachen University and Fraunhofer IPT

Allowing the executive board member to make the right decision while at the same time providing the maintenance engineers access to the latest machine data or information on recent product changes at hand.

Knowledge-based decision making at any level, event- driven decisions, adaptive processes or autonomous decisions is what we like to refer to as Intelligence. To allow for the required decision support at any moment of time, all useful Information is turned into a powerful and versatile Digital Twin of your product or production environment. But in order to provide the required information, the vast amounts of Data available at your company, must first be collected, made accessible and properly managed.

Think of the companies with the biggest digital products in the world today, and you will recognize that are all known for their innovative ways to use the data provided by their users, in order to improve the development and/or efficiency of production for their next innovation.

To be competitive in the world of tomorrow, Data generated throughout the entire life cycle of the product, from development to production and the user must be turned into Information, and in turn provide the Intelligence to make right decisions today.

The right information at any time and any place.

INTELLIGENCE

Decision Support
Digital Twin

INFORMATION

Management
Analytics

MIDDLEWARE+

DATA

Application Software
Raw Data

INTELLIGENCE

DIGITAL TWINS FOR PRODUCTS AND PRODUCTION ENVIRONMENTS

Effective and agile industrial manufacturing requires a flawless overview of all the data, information, stakeholders and perspectives that play a role in the development cycles of products and production environments. To provide engineers with a sound basis for making the right decisions in the right way, a combination of development models, simulations and real-life data is required.

Digital Twins integrate these aspects, thus coherently and consistently replicating the current state of the product or the production environment, while simultaneously being able to represent envisaged future states. The Digital Twin evolves with the development cycle throughout the entire value chain, providing structure while giving meaningful access to tools, methods and captured data. We employ the Digital Twin concept to address various system levels in the value chain, from components and products, via machines and production lines to factories, companies and beyond. By traversing these different levels, Digital Twins interrelate design, production and through-life aspects of products and production environments alike, allowing for connected decision making and understanding the impacts of those decisions in a versatile manner.

We develop Digital Twins to bring together, for example, product requirements and definition, developer insight, model-based simulations, behaviour & control mechanisms and data from IoT applications. Conjointly, this allows for dedicated and tailored understanding, visualisation and decision making for specific perspectives in the development cycle.

Digital twins can be questioned, adjusted, varied and probed while providing simulations that are independent of, but always represent, the tangible product. They aggregate findings and measurements from individual products or machines into insights that underpin and drive development cycles, leading to robust development and optimisation of products, processes and production environments.

Digital Twins allow us to develop solutions for making underpinned ‘what-if’ analyses on proposed alterations or assessed deviations in the system. This allows for effective decision making, but also enables Digital Twins to learn from the development cycle as well as from simulations and amassed feedback from product instantiations. They simultaneously follow, predict and drive development processes of products and the production environments that engender them. Therefore, Digital Twins act as the intelligent digital counterpart of reality, whether that is current, anticipated or designed.


SMART
INDUSTRY

INTELLIGENCE

VIRTUAL AND AUGMENTED REALITY IN DEVELOPMENT CYCLES

Virtual, Augmented or Mixed techniques allow users to experience situations that do not exist yet, cannot exist yet or are currently inaccessible for e.g. safety, scaling or logistic reasons. Many techniques allow for purposeful interaction – from operating a machine that is still under development, to haptic feedback on assembly activities – thus exceeding mere visualisations by far. This enables decision-making while being able to experience, explore and assess potential futures.

Merely experiencing a production environment under development from different perspectives can effectively speed up decision making while recognising and anticipating flaws in the design. In all cases, the occasion of using any VR/AR technique should lie in the actual development cycle; with that, VR/AR should foremost be seen as an extension of the tool set available to developers of products and production environments.

Many VR/AR techniques can purposefully add information to products or production environments. Examples are manifold: Providing real-time and interactive instructions for maintenance or repair of a product increases efficiency, but also renders valuable feedback to the development cycle. Integration with e.g. an ERP system to have dashboard like information on planning, performance and stand-stills of production tools or groups of tools increases decisiveness on the shop floor.

Combined with IoT techniques, VR/AR can make trace- ability of parts, products and tools instrumental, while simultaneously providing information on their statuses. Also well-known is the use of VR/AR in training situations, not only to reduce costs or downtime of production environments, but also to confront trainees with rare, extreme or unexpected situations in environments that need not even exist yet. With that, implementation time of production lines can be reduced significantly, as staff can already be trained and technical, logistic or ergonomic issues can be anticipated. If developed adequately, any training can simultaneously result in valuable feedback for the development cycle.

We develop Virtual and Augmented Reality support for decision making in development cycles for products and production environments. That main stance in this is that VR/AR is never the solution, but rather a powerful tool to adequately address the right problems at the right level of aggregation. Therefore, we cover the entire life cycle of VR/AR support, ranging from initial exploration of the problem or the need for information to the actual implementation of the adequate VR/AR tools and software, while vouching for purposive integration in the overall development cycle of the product or production environment.

INTELLIGENCE

VIRTUAL DASHBOARDS

Development cycles and production environments encompass an overwhelming arsenal of data, tools, methods and techniques. Foremost geared to better, more effective and more efficient products, equally, the improvement of development cycles and production environments are addressed. Development cycles relate to many different types of stakeholders, with different perspectives, objectives and interests. Also there are many differences in fields of expertise, language/jargon, system level, cultures and opinions that complicate multi-stakeholder decision making. Even if unequivocal information and/or Digital Twins are available, shared and unambiguous understanding in decision making is not obvious.

Additionally, decision-making easily becomes less effective and efficient because of excess information that is irrelevant for the current situation and perspective. Significant amounts of effort and time are lost in merely preparing the required information content, simultaneously addressing the impact of incomplete, uncertain and missing information. Also here, shared appreciation of the information content is often lacking.

We build Virtual Dashboards that support multi-criterion and multi-stakeholder decision making and control by providing tailored yet adaptable and flexible insight in the information that underlies decisions. Virtual Dashboards build on the realm of information, models, scenarios, simulations, tools and techniques available, allowing stakeholders to address specific subjects or aspects of e.g. a production environment.

Virtual Dashboards allow stakeholders to identify with any subset of the perspectives involved, because the insight in the information is presented in an “autorarchic” manner. This implies that the information content is filtered and presented according to perspective(s) of the specific stakeholders involved. Additionally, this has the advantage that there is no prevailing dimension or view on the system. With this, the stakeholders can choose e.g. to ‘travel with a product through the production line’, to ‘observe process conditions on a machine that show signs of wear’, to ‘focus on the overall production throughput’, to ‘relate production bottlenecks to product features’ or to ‘compare defects between machines and between product types’. With the use of Digital Twins, such observations also become available for foreseen future states of the product or the product environment.

To make the Virtual Dashboards as instrumental as possible, we apply different ways of making the information insightful. This ranges from smart information sets, via simulations, infographics, 3D models and visualisations to full-blown Virtual Reality or Augmented Reality applications. Depending on the way in which the information is accessed, Virtual Dashboards are especially appropriate to connect to and control remote locations. Moreover, a Virtual Dashboard can integrate multiple environments into one coherent entirety,

INTELLIGENCE

SERVICE-ORIENTED ARCHITECTURE

With a view to the requirements of a future “Internet of Production“, we developed a concept for an intelligent production network. The main idea is the creation of a so-called “Smart Manufacturing Network”, on whose basis all elements – machines, production systems, databases and simulation systems – can freely communicate with one another. The operators are integrated into the system through mobile devices such as tablets or smart glasses and can interact directly and in real time with all sub-systems, control them and access production data. Such decentralized and dynamic systems make it possible to plan, implement and repeatedly reconfigure manufacturing processes and process chains quickly and cost-efficiently.

Smart Manufacturing Networks are linked to the so-called “Virtual Fort Knox“, a cloud solution that has been developed at the Fraunhofer IPA in Stuttgart. This solution has been selected as the instrument for a safe exchange of data by the members of the Fraunhofer Group of Production.

With our service-oriented software architecture that provides manufacturing process technology services within the Smart Manufacturing Network, we have created a new method of designing a more flexible component process chain: During the planning stage, a preliminary process chain for the component is defined, which does not yet specify the individual machines that will

be used but only the requirements such as assembly space, number of axes and surface quality specifications. Based on measuring data for the blanks and other conditions, the software will then autonomously calculate the process data and select the correct production machine in the given line by comparing the requirements identified in the planning stage and machine availability. Only after this will be the manufacturing data for the specific machine be adjusted so that the production process can be completed.

This process ensures a high level of flexibility within the process chain and at the same time a consistent documentation of process parameters and results. The integration of tablets and smart glasses gives the operators access to all information they need to perform their jobs. The provision of such information is important in situations where the process chain cannot be automatically operated or where special authorizations are required.

Towards a smart manufacturing network

INFORMATION

MACHINE-TO-MACHINE COMMUNICATION

Industrial manufacturing still requires an enormous amount of manual support: This begins with the development of machine programs and extends through parameterization and organizing processes and cycles to manual quality control. This prolongs set up and rigging times and requires experienced machine operators, who intuitively pass on information between process stages and refer it to planning systems such as MES.

So far, very few companies have automated the connections between various process steps such as pre-machining and part measurement. In many companies, there is a lack of automated cycles to regulate data exchange between measuring systems and machine tools, integrated interfaces and standardized data formats. In order to serve these needs, we develop a new M2M technology which will enable production networks to be expanded and designed to be more adaptive. The aim is to achieve automated exchange of information between planning systems, production machines and measuring instruments without the need for humans to exert direct control.

Consistent data formats and standardized interfaces such as OPC Unified Architecture, for example, ensure continuous networking throughout the entire process chain regardless of the machines involved. The fully integrated communication solutions were developed in accordance with industrial standards and also feature robust, operator-friendly control solutions for the implementation of higher levels of automation.

Total data consistency throughout the micro-structured freeform optics was achieved, for example, within the framework of the trans-regional special research field SFB/TR4 “Process Chains for the Replication of Complex Optics Components”. The process steps and in particular the range of manufacturing, replication and metrological machine systems were all interconnected in one network and linked to the corresponding planning systems.

Data structures and interfaces for machine and system connection

INFORMATION

BIG DATA AND PREDICTIVE ANALYTICS

Automated systems for the collection and analysis of machine, tool and quality data contribute to the enhancement of product and process quality. Frequent reference is made to the "Single Source of Truth" in the context of Industry 4.0. All relevant production data are filed once, in structured form - completely free of any redundancy. Only when this has been achieved, is it possible to conduct detailed and purposeful data analyses.

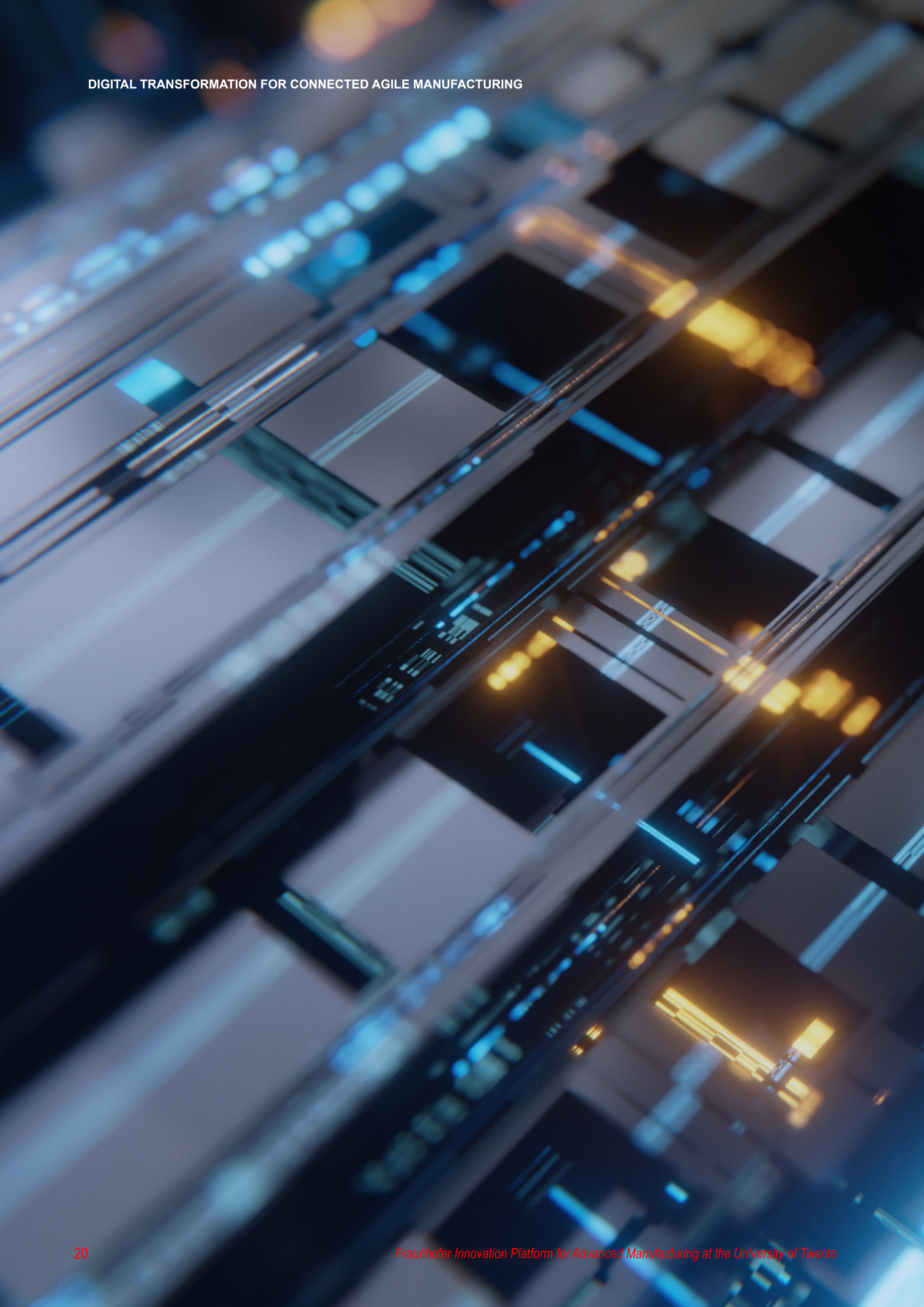
We develop and implement systems of this nature for a range of technologies and manufacturing methods. Interactions and dependencies within the whole manufacturing chain are revealed using appropriate data analysis software and potentials for optimization are derived as illustrated by the example of a technology database for the manufacture of replicative optics.

The technology database for the precision molding of optics contains information relating to all processes up and down stream such as the preparation of the forming tools via machining processes, tool coatings, quality analyses of the optic and of the forming tool decoating. This is achieved by recording all relevant product and process parameters along with their quality indicators in the technology database. The information is connected and filed clearly in the form of relational data structures - fully in accordance with the principle of a "Single Source of Truth". A user-friendly frontend permits historical data records to be swiftly retrieved via filter functions.

In order to identify patterns and dependencies within the process chain, a standardized SQL database with data-mining software such as "Rapid Minder" is used to evaluate these data records.

Thus optimum parameters, process conditions and process strategies for increasing the efficiency of manufacturing and product quality can ultimately be derived from neural networks, decision trees or correlation analyses and fed back into the system. The technology database and the subsequent analysis operation permit end-to-end data acquisition, holistic analysis of production data throughout the process chain and the derivation of optimum process settings. In comparison with the outcomes of conventional approaches such as Design of Experiments (DoE), the basis and quality of the data available for the identification and analysis of process dependencies and optimum parameters are considerably more wide ranging and detailed.

Optimizing products and processes via data mining and predictive analytics



INFORMATION

DATA CONSISTENCY IN THE CAx PROCESS CHAIN

Computer-assisted process chain planning and design via software systems are more important than ever in the age of Industry 4.0. In recent years, there has been a shift in computer-assisted planning of process chains (CAx) from fixed to flexible manufacturing process chains. In accordance with the principle of "mass-customization", manufacturing process chains must adapt dynamically to inputs and disturbances in order to achieve the expected outcome. The fundamental requirement for continuous, flexible CAx process chains is data consistency.

A repair process chain must adapt to the specific details of the damage sustained by the part which is to be repaired for example. This is the point at which the traditional approaches pursued by the CAx programming are stretched to their limits: Manual adaptation of manufacturing process chains to particular products, cases of damage and disturbances is a costly operation and the development of specialist software for certain products or product families quickly breaks the budget of most companies.

Additive manufacturing methods such as laser deposition welding are the obvious choice for the repair of turbomachines used in aerospace or for energy generation. This involves first removing the worn and defective areas of the turbine blades and then reconstructing it so that is corresponds with the original nominal geometry.

Within the framework of the "Adaptive production for resource efficiency in energy and mobility - AdaM" innovation cluster, we have collaborated with over 20 project partners to develop a continuous part and process data chain for adaptive machining. A digital image of the actual part including the manufacturing information, which is also required, was first generated in a product data model. The production process can be simulated in a virtual model on the basis of this data during the work station phase in order to acquire information about the contact conditions of the milling tool. This shortens the ramp-up period and reduces the need for costly preliminary tests on the actual part.

We improve the data consistency in the CAx process chain by developing and using a "CAx-Framework" for planning and simulation. With the appropriate software modules, the framework links various manufacturing processes to continuous, computer-assisted process chains (CAx process chains). The workflow-based programming method deployed, enables the user to design process chains in a flexible and user-friendly way. The laser deposition welding and milling processes, for example, can be linked to form a continuous CAx process chain on the basis of the CAx-Framework. This ensures data consistency throughout the entire product lifecycle. The data are made available to the appropriate employees via a product lifecycle management system (PLM).

Data consistency speeds up the development of the right product


Smart Industrial Control System
Dashboard
Overview
Product report
Performance
Product Quality
Machine State
Machine 1
Machine 2
Machine 3
Monthly Summary
Product Quality
Performance
32.04%
99%
Power consumtion
Machine State
25%
67%
Fine

DATA

IoT AND CYBER-PHYSICAL SYSTEMS

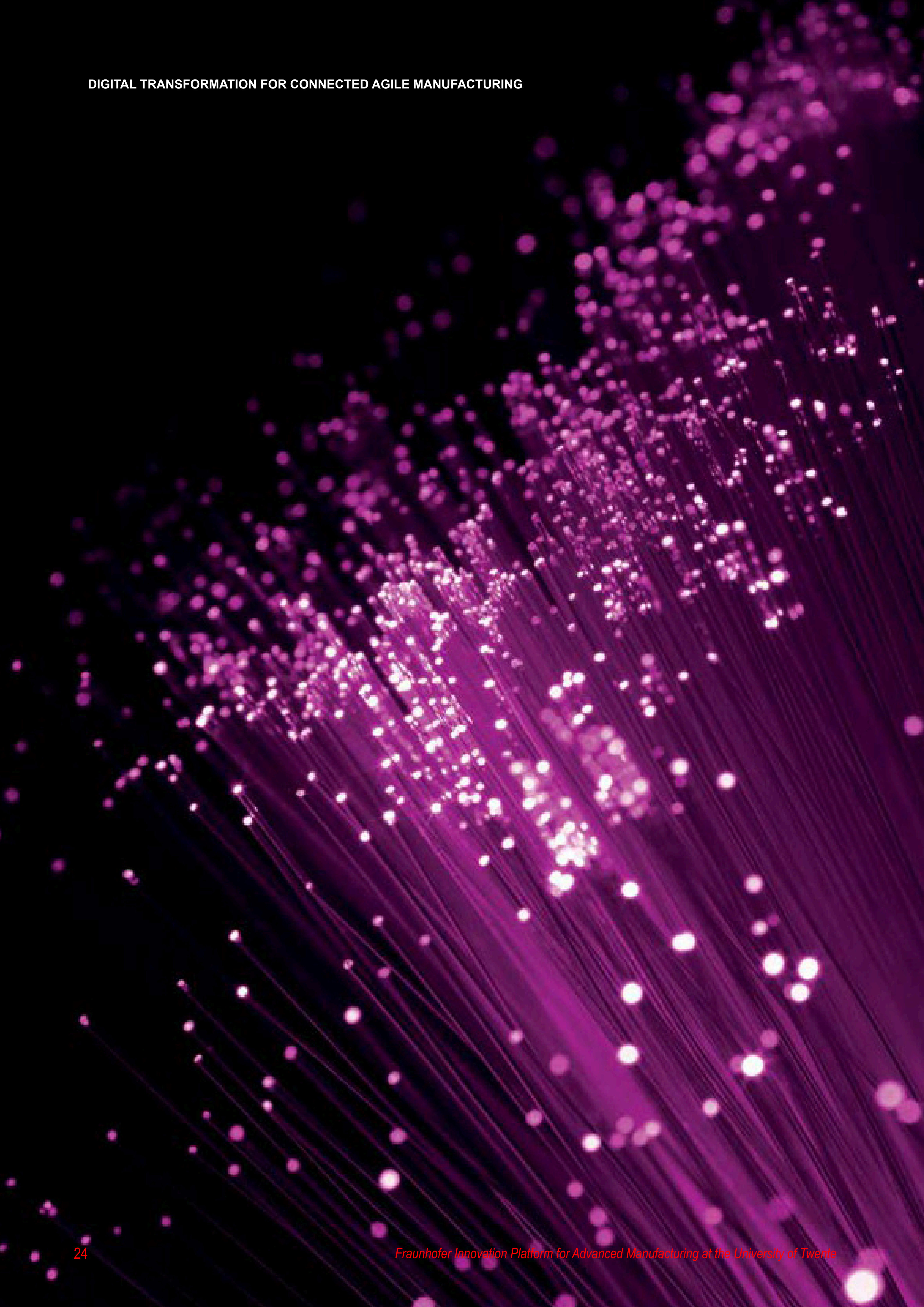
Our society and economy rely more and more on integrated ICT systems. In the (recent) past, ICT supported primarily all sorts of administrative processes. However, at fast pace, ICT takes control of almost all physical processes in society and economy as well. Think of our energy supply, logistics processes, transportation and manufacturing and industry in general. With the term cyber-physical systems (CPS) we denote exactly these systems that feature a tight combination of, and coordination between the system's computational and physical elements and the system's environment. The concept of the Internet-of-Things (IoT) is closely related to that of CPS. However, with the term IoT, one often focuses more on the sensory part of an CPS.

Cyber-physical systems form the hearth of modern systems in aerospace, automotive, the process industry, civil infrastructure, energy systems, healthcare, manufacturing, transportation, entertainment, and communications. CPS are at the core of Industry 4.0. It is for all these application fields crucial that these CPS always and probably work correctly, such that reliance can justifiably be placed on them.

We have great expertise in the design and implementation of communicating computational elements (both hardware and software for both communication and computation), taking into account the foreseen interaction with a physical environment and driven by application constraints. The thus resulting integrated approach towards design and implementation allows us to increase the overall CPS' adaptability, autonomy, efficiency, performance, functionality, reliability, and their security and safety.

Examples of CPS include communicating manufacturing and production systems, systems to track and analyse emission, communicating sensor systems, systems to provide situational awareness (first responders, navy), systems to measure and control (air) traffic, or measure and control complex infrastructural systems such as energy and water supply systems and large-scale networking systems or large-scale server farms. Some CPS exhibit inherent mobility; examples include mobile robots, wearable electronics, or mobility/transport solutions ("connected cars").

Key cross-cutting systems properties addressed in all CPS are related to performance, energy usage, size, cost price, maintenance, operations, dependability, security and safety. It depends very much on the application at hand, how trade-offs between these properties are made.



DATA

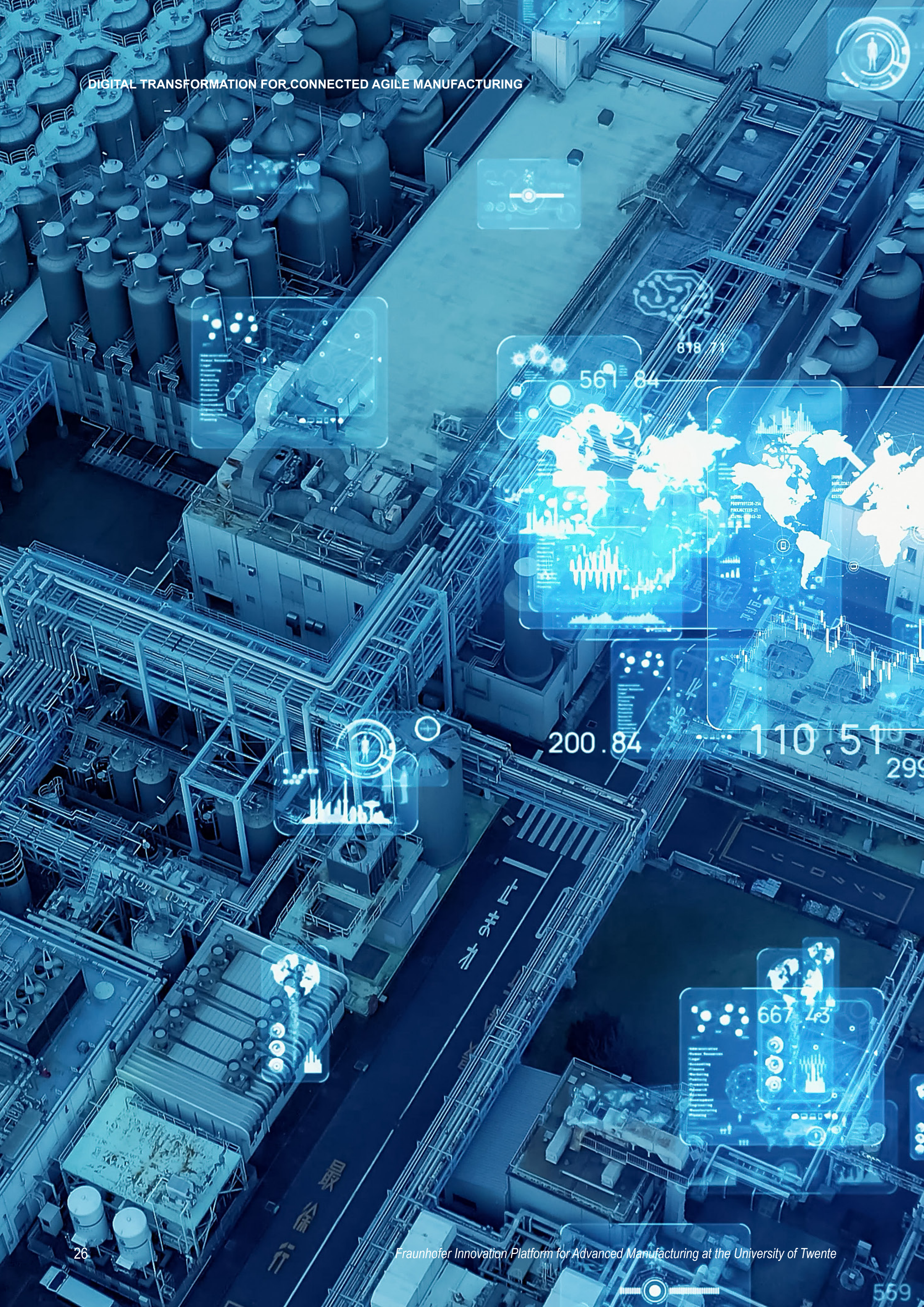
CYBERSECURITY AND TRUST

Cybersecurity for Industry 4.0 has many elements, some fairly generic, other specific for industry 4.0. One of the key things to address is the general protection of industrial IT infrastructure. With our expertise, we are able to protect general IT infrastructure against, for instance, DDoS attacks (distributed denial-of-service attacks), phishing and spam.

Identity management, privacy and support for safe and secure transactions is required, which relates to recent developments in e-currencies and blockchains. We work on state-of-the-art knowledge in a large number of national and international projects, also involving major commercial parties.

The protection of SCADA (supervisory control and data acquisition) networks, that is, the networks that actually monitor and control industrial plants need further development. Often not (yet) designed with security issues in mind, many industrial installations are not very secure. We develop a large variety of techniques to improve the security of industrial control systems and networks against intruders, thereby combining our expert knowledge on networking technology and security for classical IT systems, with knowledge of the processes being monitored and controlled.

Finally, safe and secure sharing of data, or parts of data, along the supply chain is a key challenge for many large OEMs and their suppliers. Although (in part) appropriate safe and secure data sharing approaches do exist, their application is hampered by many practical (often business) concerns. Our application orientation and an integrated approach to bring industrial plant, supply chain designers, IT specialists and business specialists together, allow us to provide the right solutions.


200.84
110.51

DATA

VBOX – RETROFITTING FOR INDUSTRY 4.0

In the world of Industry 4.0, sensors must be able to pick up and synchronize data in and around machines with very high levels of accuracy. These data are then fed in real time into a data processing network which enables the system to develop an instant and autonomous response. Many companies are afraid of losing touch with the latest technological developments and are replacing their fully functioning and relatively new equipment with even newer machines that can be readily connected to production networks.

With the vBox, we are able to eliminate the need for companies to replace machines and equipment, which are still in perfect working order before the end of their tool life. The device provides production systems with networking capabilities, equipping them for Industry 4.0 and saving machine operators considerable costs - both in serial and single-part production.

The vBox complies with all current industrial standards: The compact system can synchronize both positional data and input and output data with information received from the sensors, display the outcome for the user on demand - regardless of the control technology used. Top-quality, machine-related data and information on force, structure-borne sound or acceleration are transferred in real-time, so that any malfunctions and critical points in the process can be detected and optimized without delay. This provides a basis on which companies can even plan and optimize schedules for operators and service staff individually.

Ramping up a new serial production line, monitoring processes for manufacturing high-value components or carrying out predictive sub-assembly maintenance are just a few examples of immediately apparent vBox uses. The complete integration of the vBox within existing production control systems makes a major contribution to transparent manufacturing as envisioned by the Industry 4.0 strategy.

DATA

5G-DATA TRANSMISSION IN PRODUCTION SYSTEMS

Most discussions about Industry 4.0 tacitly assume that any such system will involve the processing and evaluation of large data volumes. But while modern sensor technology may already be capable of collecting a wide range of machine and production data, it is proving more difficult to analyze this information comprehensively in a single data control center and to feed the results quickly back into an optimized production cycle. This is why the conversion to flexible and adaptive manufacturing processes requires fast, reliable and (preferably) wireless data transmission systems.

The forthcoming 5G mobile communications standard appears to be the perfect fit for the complex measuring and control technologies of connected, agile production lines, providing short latencies (of less than one milisecond), high data transmission rates (up to 10,000 megabits per second) and the possibility of operating many devices simultaneously in narrowly restricted radio cells. In close cooperation with the Swedish mobile communications provider Ericsson, we are developing and testing scenarios for the industrial application of 5G in realistic production environments.

The operation of high-precision machine tools in complex production processes requires stable and reliable communication systems. 5G technology is making it possible to introduce wireless sensor technology into industrial environments on a grand scale, paving the way for real-time data analyses and adaptive manufacturing control systems with short response times. Ericson - one of our partners in the International Center for Networked Adaptive Production – plays a leading role in the development of the 5G standard and 5G products.

It is our common objective to test the technology with the explicit aim to apply it in industrial environments and to develop it further for a range of individual applications that require the integration of machines, production systems, data transmission systems and databases into networks of mutual communication.

Robustness and real-time capabilities for connected, agile production processes

USE-CASES

VISUALISATION AND SIMULATION

Product and production environment developers alike face considerable challenges in understanding the current state of affairs in their development cycles. Influenced by many different stakeholders and extensive sets of data and information stemming from different systems, it is far from trivial to assume that everyone involved in the development cycle can decisively address the appropriate decisions at the right time. Moreover, in assessing possible variants, potential futures or different scenarios, the magnitude of the data and information realm can quickly multiply beyond control.

The Virtual Reality & Smart Industry Laboratory at the University of Twente offers solutions that bring together a multitude of tools and techniques to purposefully support decision making in development cycles. Here, the main approach is to present information for decisions in a format that matches the perspectives of the stakeholders involved. Often, knowledge visualisations and simulations help developers to quickly understand complex situations, helping them to prioritise decisions and to estimate their consequences. This is all the more true for situations that in reality exist at a different scale, at an inaccessible location or different time or at a different speed. In many such cases, visualisations and simulations smoothly merge of flow into one another, cojointly rendering the perception for the stakeholders.

Visualisations and simulations are the basis of so-called Synthetic Environments, being design environments that bring together real and virtual components to allow for adequately experiencing shared information. In their simplest form, Synthetic Environments enable stakeholders to observe e.g. products or production environments that do not yet exist. Such environments become more instrumental if additional layers or renditions of information are added, allowing for the integration of analyses related to e.g. manufacturing, strength & stiffness, heat flow, ergonomics, safety, logistics or environmental impact.

More complex instantiations of Synthetic Environments include full-immersive experiences, employing a wide variety of Virtual or Augmented Reality techniques to present information in a meaningful manner to the developers and stakeholders. We provide structured approaches to effectively and efficiently build Synthetic Environments. This approach is applicable under many different circumstances, whether it addresses e.g. a walk-through to experience, assess and interact with a production environment under development, ‘travelling’ with a product being manufactured to research the impact of subsequent production processes, to study organisational or logistic impact of design decisions, to do market forecasting for products/portfolios, to train staff or to allow for any form of multi-stakeholder decision making.

USE-CASES

LOWERING PRODUCTION COSTS VIA SMART CONTROL ALGORITHMS

Developments such as increasing diversity in the range of variations available or new supply concepts from the energy sector are driving demands for the capacity to provide vast amounts of information swiftly and, in some cases, globally. Classical goal criteria used in production planning such as machine utilization or throughout time are accompanied in the age of Industry 4.0 by further information relating to factors such as time-related risks or energy consumption. New production planning and control concepts which take account of these data can make a major contribution towards lowering production costs.

We develop concepts of this nature, which make it possible to incorporate these goal dimensions. Only when all of the corresponding production data are available, when ERP, machine and operation data, energy controlling and MES have been networked, will companies acquire a completely new level of transparency regarding their production facilities and processes.

Along with our partners in the “eMES” research project we are therefore extending the production planning and control area to include energy-oriented order planning which, in conjunction with smart grids, will continue to permit flexible energy and cost efficient planning even in the face of rising energy costs.

Short reaction times and control loops are essential elements in the ability to react adequately to load peaks. To achieve this, it is vital to ensure that operating and machine data, product-related master data and machine-related energy data are available – in real time, if possible. To this end, ERP and machine-oriented energy measuring systems are connected to the central MES and appropriate interfaces are developed. Transparency can thus be achieved in relation to the current production progress status, capacities and energy consumption. The opportunities and risks associated with direct intervention in load management can be utilized via synchronized communication with the energy suppliers.

Taking account of new variables such as time uncertainties and energy costs

USE-CASES

AUTOMATION IN COMPLEX PRODUCTION ENVIRONMENTS

The concept of interconnecting and monitoring process chains in control units and control stations is already well established in some sectors of industry and in some applications, particularly in continuous process engineering. Continuous data acquisition for flexible and adaptive control of discreet and highly automated process sequences – even in complex production environments, is part of Industry 4.0. The cultivation of living cells is an example of process sequences in complex environments.

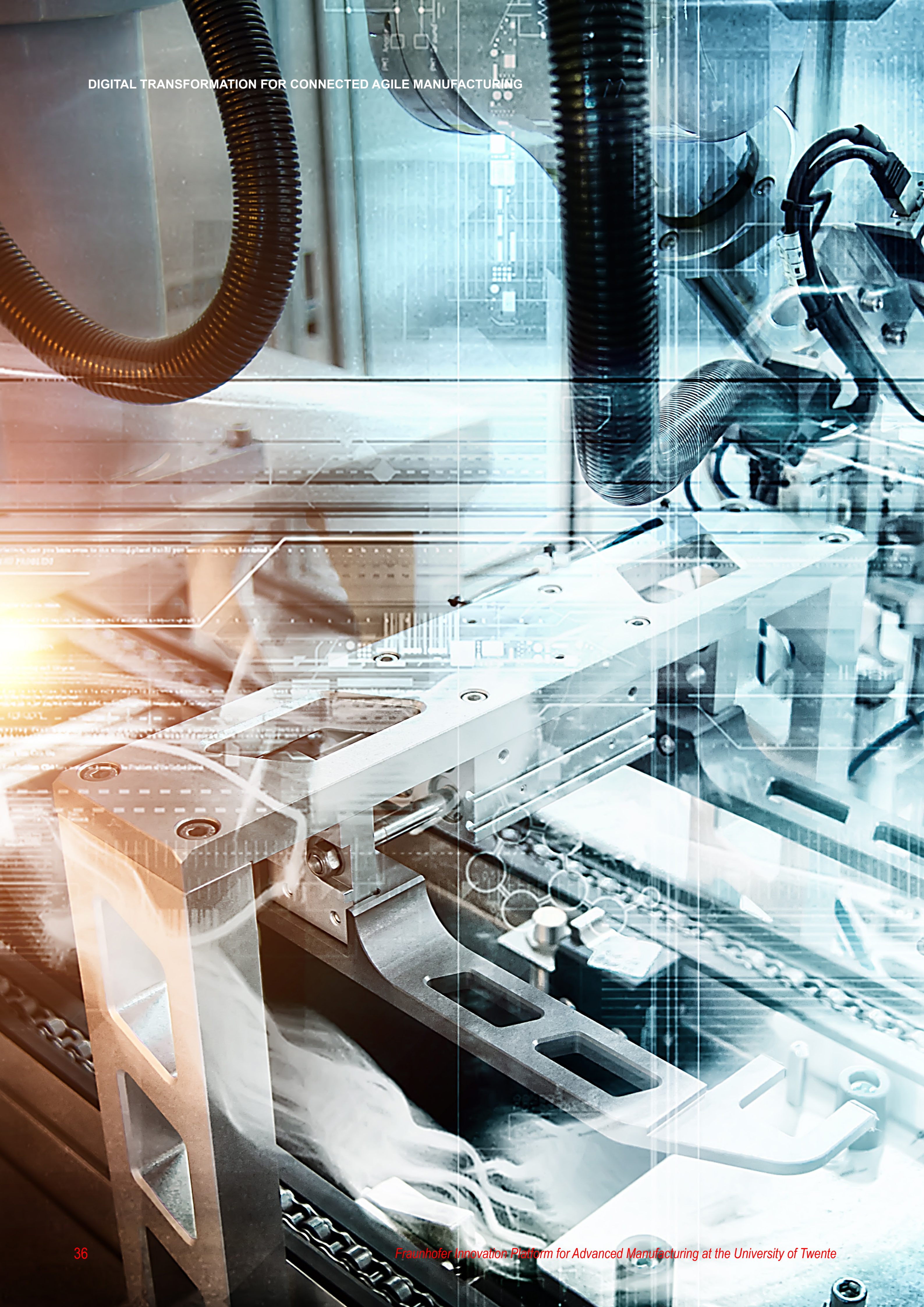
Process automation and control in cell technology is a critical venture: influencing factors such as cell density, temperature, humidity and gas concentration as well as the very marked genetic individuality of cell products, imposes exacting demands on the process control operation. A high degree of networking among individual devices and seamless integration of metrology within process control, are major prerequisites.

In the collaborative “StemCellFactory” project, we developed a fully automated production platform for the production of stem cells. This platform has numerous quality assurance and cell processing components, which are interconnected via a central control station. Each cell colony is measured continuously and the process parameters are repeatedly adapted automatically on the basis of measuring results. The control station developed specially for this purpose controls the entire process and monitors the devices and material used throughout the entire production process. The user is informed automatically by the system if the volume of resources - the fill level of process media, for example - falls below a specified level. The device resource management system automatically applies an automatic scheduling algorithm.

In addition to the quality assurance and processing devices, the platform has a range of basic functionalities at field level and some safety-relevant systems equipped with a programmable logic controller. This is integrated within the production platform as an additional module and is connected with the control station. In addition to this, the platform has a range of logging functions which ensure data consistency at process and device levels. The data are collected, processed and saved systematically. A user-friendly operator interface displays these data to the operator and supports the evaluation of the data.

The “StemCellFactory” is an example of how even highly customized production processes can be designed, with connected, adaptive systems, to be extremely flexible and efficient.

Controlling highly individual production processes



USE-CASES

DIGITAL STRATEGIES AND BUSINESS MODELS

Industry 4.0 technologies pose significant challenges and opportunities for many companies across all industries. Many of the challenges that are on the executive agenda are related to the operational level of the firm and focus on the integration of new technologies with existing ones in ongoing business operations. The business model and its changing position in the value chain often remain out of scope.

Industrial shifts with the magnitude we are facing today in the form of the fourth industrial revolution requires at least a revision of existing business models as well a review of the current and future position in the value chain. In other words, exploiting Industry 4.0 technologies cannot happen in isolation or be driven by operations only. Next to technology-related considerations, companies should consider how to implement Industry 4.0 technologies based on a strong business model and how to co-create superior customer value in the value chain together with their customers and suppliers.

Examples of disrupting trends regarding this topic in the Industry 4.0 context are manifold. These include the trend of “as-a-service” business models, enables by technologies like sensors and advanced data analytics. Another trend is the transformation of value chains into value networks. This results in increased complexity of value co-creation as business models of other players in the value network must now be considered.

Our focus is to help industrial companies with their ambitions to thrive in and drive the emergent Industry 4.0 revolution. We evaluate your digital strategy, your business model and identify new possibilities to create value in the context of Industry 4.0.

Identifying future business models for sustainable growth

USE-CASES

SELF OPTIMISING PRODUCTION PROCESSES

Self-optimization is an important control principle in adaptive systems. The extension of classical control principles to include autonomous goal redefinition makes it possible to establish artificial intelligence in technical systems. In conjunction with the availability of real time information, this paves the way for the creation of robust and at the same time flexible production systems even in highly dynamic Industry 4.0 environments.

Within the "Integrative Production Technology for High-Wage Countries" cluster of excellence, we investigate new means of applying the principles of artificial intelligence to expand significantly the range of applications and services in which closed control loops can be used. The overriding goal is to make machines and equipment more autonomous and more intelligent in order to enhance their flexibility as well as their robustness when exposed to interference factors. Self-optimization as an approach to flexible and reactive automation makes an important contribution in this context.

Assembly is a classical field of application. We develop and apply principles of self-optimisation for the assembly of high-performance optical systems. High-precision orientation of optical components is one of the crucial quality criteria for the assembly of such laser systems. It is vital to meet the most exacting demands in terms of manufacturing and process tolerances. Self-optimizing assembly systems can rise to the challenge by using models to interpret the sensor data. This is achieved by drawing on the optical characteristics such as beam profile, optical power or imaging quality, evaluating them and using the results in a closed control loop in order to correct the position of individual optics. In a self-optimizing system, tolerance minimization is replaced by function-oriented assembly process management. As a result, the planning effort required for complex assembly processes can be greatly simplified whilst maintaining a robust production system.

In collaboration with our partners in the cluster of excellence, our scientists transfer the principle of self-optimizing control from production processes to a number of other applications – from assembly through welding to optimization of weaving looms. The goal of the research work is always to achieve a significant reduction in the effort and cost involved in the initial process set-up. In this case, a previously unattainable level of flexibility can be achieved - and with it, an important step toward the automation of low volume production series and the manufacture of individual products. The intensification in control of these processes in comparison with that achieved in classical applications increases their robustness and therefore their reliability very considerably, even given the rapidly changing parameters in highly flexible factory operation.


79%
63%
74%

USE-CASES

DIGITAL TWINS IN THE TURBINE COMPONENT MANUFACTURING

The main objective of all processes to manufacture high-tech products in compliance with the specified ranges of permissible variation. For this purpose, all data that might provide some evidence of status changes anywhere along the process chain must be recorded. Sensors in machinery and equipment can provide valuable clues as to whether or not the actual values will fall into the tolerance range.

In turbine component manufacturing, all data from sensors and the production system are stored individually for each product, creating a digital twin that retains a full production history including project data and order specifications. Identification systems allow this twin to be assigned to the individual component, making it available for every downstream process step. The extended product data models provide relevant, context-specific data from the manufacturing history for further analyses, accelerating process development and process optimization in the production of prototypes as well as large series.

In order to serve the mass production of turbine components, we focus on real time production data generation for the development of more efficient process chains and the provision of evidence for the compliance with certification requirements. Data are gathered through the use of standardized interfaces and are available for simulations and documentation purposes along the entire process chain.

In the production and repair of gas turbine blades we analyse the application of virtual planning tools such as process simulation and process chain reconfiguration for additive and subtractive manufacturing or repair processes including milling and laser metal deposition (LMD). By providing detailed logs of real data from the processes under review, it is possible to recognize patterns which reveal where adjustments along the process chain may be beneficial. Optimized planning tools benefit from data consistency and ensure high levels of transparency in the planning process.

Our developments are focussed on the detailed recording and storage of all relevant process data from the manufacturing chain and the more immediate use of information about manufacturing errors and component defects in order to identify the critical manufacturing steps. In this way, we enable customized and adapted processes based on the knowledge of entire product histories throughout the product life cycle leading to higher levels of machine availability, lower downtimes and quicker response times following breakdowns through predictive maintenance of machine tools.

ABOUT US

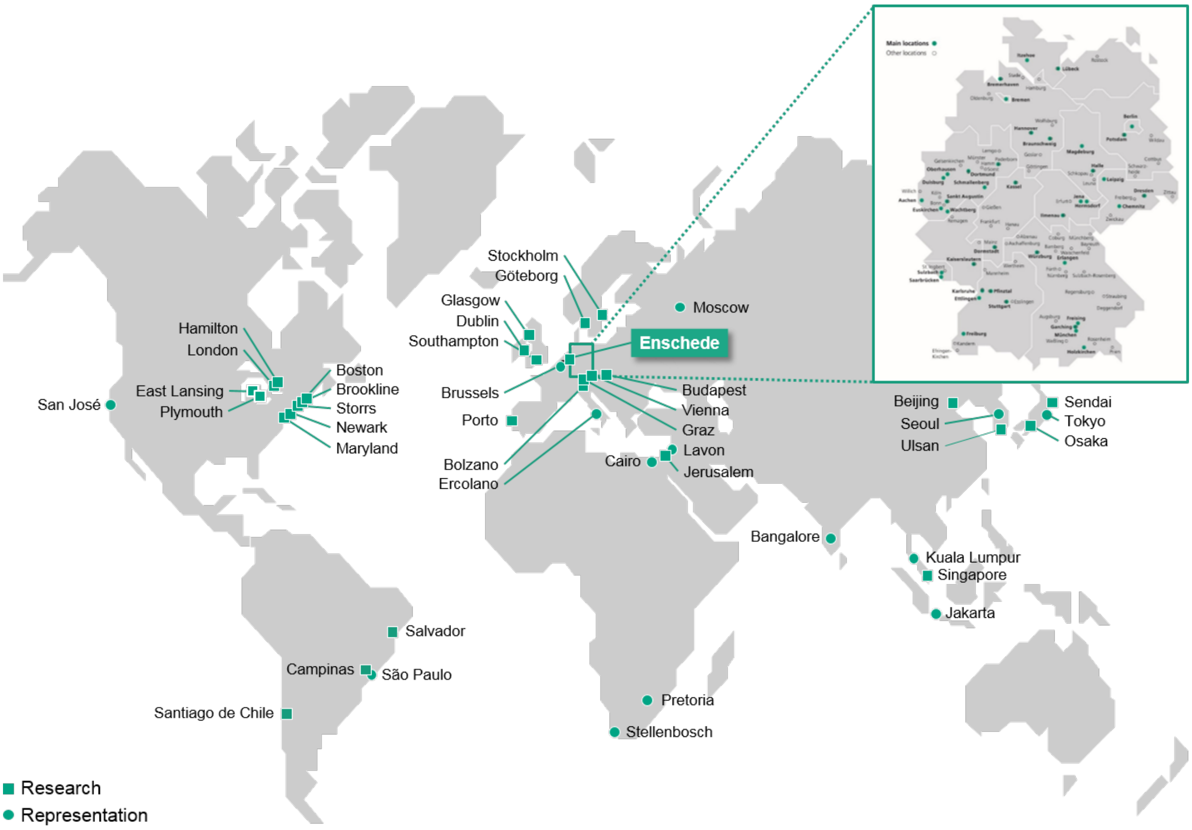
Originally known as the Fraunhofer Project Center at the University of Twente, the Fraunhofer Innovation Platform for Advanced Manufacturing emerged in 2022, continuing the strong collaboration between the Fraunhofer Institute for Production Technology IPT in Aachen and the University of Twente in the Netherlands.

The Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT) is a research centre that collaborates with manufacturers to develop innovative and integrated solutions to serve and strengthen the industrial manufacturing community and benefit society as a whole.

FIP-AM@UT's primary goal is to strengthen and diversify the manufacturing sector in the Netherlands to ensure ongoing adaptability, competitiveness and efficiency. This can be accomplished by bringing highly skilled researchers and supporting staff to the region.

Their secondary goal is to source and develop innovative thinkers by engaging them in cutting-edge applied research for both industrial and public clients, and by promoting technology transfer through the joint exploitation of results.

FIP-AM@UT is part of the University of Twente (UT), the only campus university in the Netherlands. Divided over five faculties, it provides more than fifty educational programmes. In addition, UT has a strong focus on personal development, aiding and encouraging talented researchers to conduct groundbreaking research.



PARTNERS

UNIVERSITY OF TWENTE

The University of Twente is a modern, entrepreneurial university, with 3,000 researchers and professionals and over 10,000 students, leading in the area of new technologies and a catalyst for change, innovation and progress in society. The university's strength lies in its capacity to combine and work on future technologies. The University of Twente is home to powerful research institutes at the forefront of nanotechnology (MESA+), ICT (CTIT), biomedical technology and technical medicine (MIRA), governance and behavioral sciences (IGS), geo-information sciences and earth observation (ITC), and science based engineering.

FRAUNHOFER NETWORK

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 72 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of more than 25,000, who work with an annual research budget totaling 2.3 billion euros. Of this sum, almost 2 billion euros is generated through contract research. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

FRAUNHOFER IPT: INSTITUTE FOR PRODUCTION TECHNOLOGY

The Fraunhofer Institute for Production Technology IPT in Aachen has decades of experience in the production technologies it utilizes to provide companies with a strong basis for the digitization of production processes, machine tools and equipment. Technological expertise is complemented by new production organization methods and by the design of industrial software systems. The institute currently employs around 460 people who are dedicated to applying their creativity to methods, technologies and processes for a connected, adaptive production.

UNIVERSITY
OF TWENTE.

FRAUNHOFER
INNOVATION PLATFORM
FOR ADVANCED MANUFACTURING

fip@utwente.nl

fip.utwente.nl