top engineer

The Elomatic Magazine 2 · 2019

Digitalisation issue

Progress requires greater levels of intelligence and wisdom.
– Jussi Soininen

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Riding the wave of digitalisation

We live, as they say, in exciting times. All around us we are witnessing societal changes driven by digitalisation. At Elomatic, digitalisation is something that allows us to create better and more sustainable solutions for products and processes. Digitalisation is, as such, not a goal in itself but a means to achieve improvements and efficiency gains.

Many consider the vast changes brought by digitalisation as evidence that mankind is on the cusp of a fourth industrial revolution The Fourth Industrial Revolution is touted to be as significant as those that came before. It is set to build on and enhance the impact that digitalisation has brought to our society. A key feature of this revolution is the myriad ways that technology is becoming embedded and interconnected in society, in the way we live, work, spend our free time, and the products we buy and services we use.

We are seeing an equally significant impact on industry and business in general, where business models and value chains are being transformed.

As engineers, we are particularly interested in how the Industrial Internet is evolving with the connection of machines and equipment to each other and the network. Our interest extends to how digitalisation is impacting automation data processing, cloud services, ERP systems, process optimisation with artificial intelligence, as well as the use of digital twins for process and equipment development and operational control.

The area of digital twins is particularly fascinating. The definition of digital twins varies somewhat. To some it is the structural model of a product, or an operational and maintenance model, while to others it is a model that simulates the real-world behaviour of a facility or product. This magazine contains articles with examples of all these kinds of digital twins.

Elomatic's daughter company, CADMATIC, has developed its eShare solution that serves as a platform for the creation of digital twins. In this solution, the facility or vessel 3D model acts as a central hub that can be integrated with all other operational systems. Elomatic has also developed its own information management system EloWise, which in many respects acts as a digital twin.

With the digital revolution, security concerns are becoming increasingly prominent, something which we are keeping a close watch on. Despite the risks, digitalisation remains an opportunity above all else.

This digitalisation issue of the Top Engineer magazine is packed with interesting articles that ponder the impacts of digitalisation on how engineering and consulting services are rendered, what new solutions it has enabled, and what the future holds.

I hope that you will enjoy this special edition of our magazine and welcome your feedback.

Patrik Rautaheimo
Editor-in-Chief
CEO

Contents

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Cover: Jussi Soininen works at the Elomatic Headquarters as a Chief Design Engineer, Information Systems. Cover photo © 2019 Olli Tuomola / Elomatic.

Leveraging the benefits of digitalisation

Industrial Internet, automation data processing, and cloud services

Text: Markus Havupalo

Society is currently undergoing a digital revolution which, in addition to changes in our environment, is creating and transforming industrial business models and value chains. The Fourth Industrial Revolution will transform the Industrial Internet (IIoT) by connecting real-world machines and equipment to each other and the network.

This article addresses the requirements of cloud services and automated data processing for future automation assignments in industrial applications to fully leverage the benefits of digitalisation for the benefit of the customer.

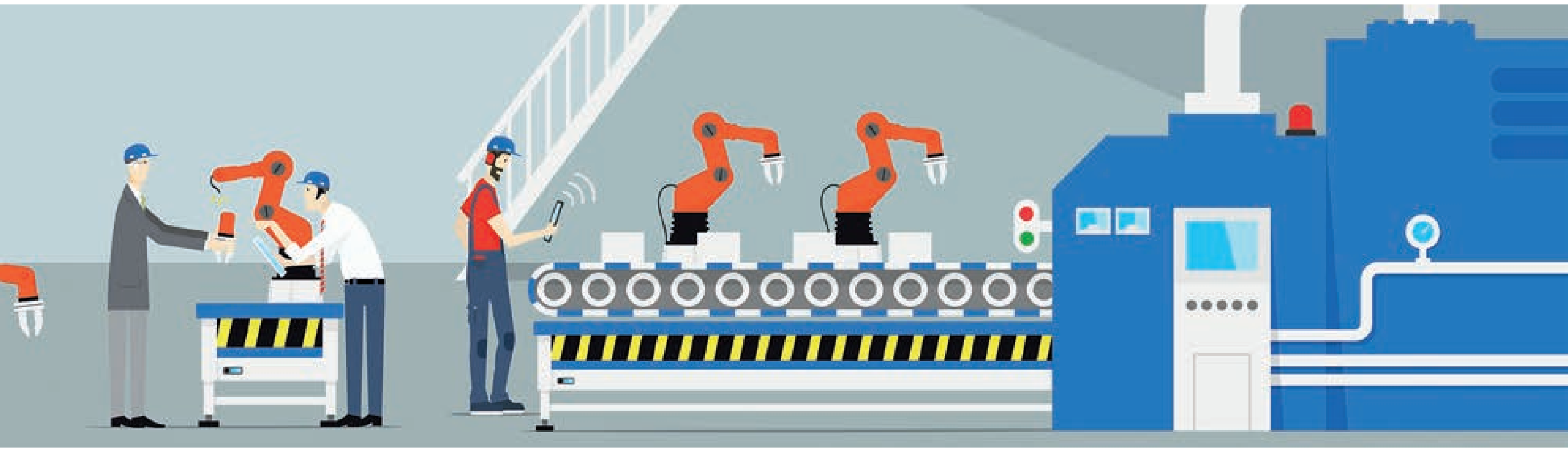
As I drive to work in the morning, I notice people locating and renting electric scooters on their mobile devices in light urban traffic. At the same time, the radio presenter reports on the latest digital breakthrough. On my way home, I pick up food in a pre-packaged bag at the supermarket with the food I selected the night before on my computer. I notice that my hometown in Turku, Finland, is part of the technological revolution that is changing cornerstones of our environment that were considered constants.

The combination of external, cloud-based artificial intelligence with smart mobile devices – even electric scooters – has created new business models and value chains in civilian life. Companies from all sectors are trying to get their share of the spoils. Industrial companies have also seen the potential created by digital technology development to enhance, grow and improve their reliability and business operations.

Fourth Industrial Revolution

Traditional industrial automation is once again on the verge of a new revolution, which will significantly expand the requirements for industrial automation supplier competence, tool competence and partner networks. The first three revolutions in the industrial sector have brought production processes under the control of industrial automation through the use of steam and the introduction of electrical power.

Conventional assignments in industrial automation have so far included field automation design, process control system and user interface design, as well as software design. However, the scope of delivery of a data cluster is mostly limited for financial as well as traditional reasons, such as prejudice and cybersecurity, within the boundaries defined by the manufacturing



facility or the group. The Fourth Digital Revolution will transform IIoT by connecting real-world machines and devices to each other and the network.

Due to the measurable business benefits of these developments, the traditional concept of the industry-wide data cluster will be expanded, especially for cloud services. This will, of course, require rethinking, for example, in relation to information and cybersecurity. The IIoT and the Internet of Things (IoT) are basically the same thing, but IIoT needs to consider industry-specific requirements such as system reliability.

Industry 4.0

Launched in Germany in 2013, the term Industry 4.0 is used worldwide to describe an industrial internet revolution based on the integration of advanced automation solutions with cloud platforms, advanced analytics, artificial intelligence and augmented reality.

Its mission is to develop flexible and customised future manufacturing systems, integrate different customer and subcontractor networks for added business value, and integrate products and services into hybrid products.

Requirements for automation assignments

In the future, industrial automation suppliers will, in addition to traditional tooling skills, be required to have networking capabilities and a strategic partner network to complete commissions. This is needed to fully leverage the benefits of digitalisation for the benefit of the customer.

Digital cloud services provide a new way for third-party and fourth-party providers to leverage applications and build powerful integration interfaces between parties. Simultaneously implemented database cluster options are growing exponentially. If a client's data cluster is large or has multiple layers, it is necessary to implement higher-level platform solutions to combine information from subsystems before storing it in a local database or cloud service. In addition to traditional desktop applications, the information should be accessible through mobile applications, anytime, and anywhere.

At Elomatic, we are responding to this challenge with our partner network by providing the tools and the required technology know-how under one roof from concept to detail design. In many process and food industry plants, we can complete the package with process know-how. The EloWise product family is a good example. It was developed specifically for the needs of data integration, data collection, reporting, proactive maintenance and production control.

Commercial and open-source tools

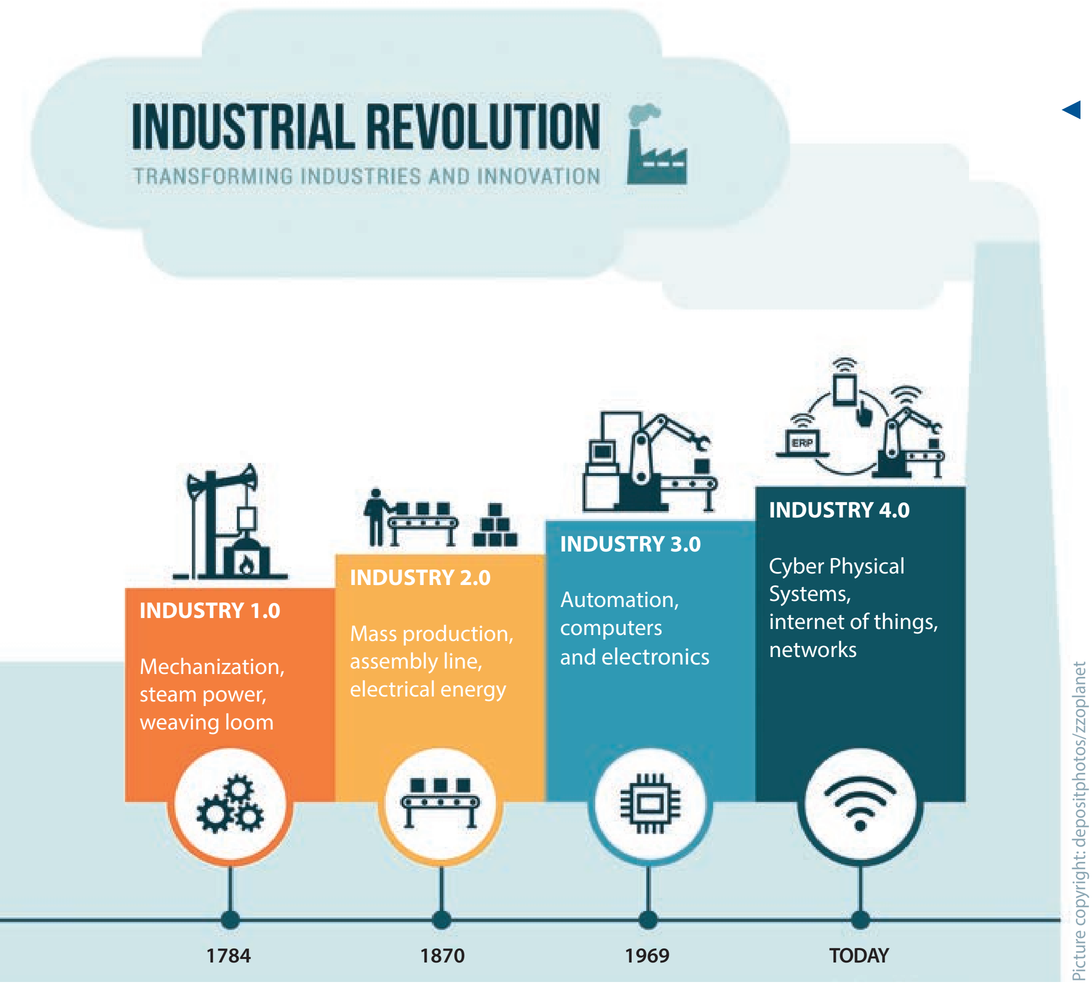
In addition to in-house service products and applications, which can be published even through online application stores, automation solution providers will also be required to have knowledge of open-source tools developed by commercial and development teams. Only by mastering cross-technology in its entirety, can data integration, visualisation, analysis, and data reporting in a cloud service or local database be designed and implemented in a competitive manner.

Diagram 1 illustrates the hierarchical levels of data processing and processing needs. At industrial sites, data collected from the field via sensors or other data sources is read from an automation system such as the Siemens PCS7 / TIA Portal, Honeywell, DeltaV process control platforms via an OPC (Open Platform Communication) interface. An extension of the OPC communications protocol is currently being planned that is independent of manufacturers and includes real-time field devices. This is possible with the new OPC UA (Unified Architecture) over TSN protocol. Experts consider OPC UA TSN technology as the means for future communication in Industry 4.0 and IIoT.

Cloud Services

In cloud services, read data is transferred to a cloud database via a dedicated router. AWS (Amazon Web Services), Microsoft Azure, and Google Cloud are currently the most widely used cloud platforms worldwide.

Automation system vendors also offer their own cloud services that run on top of one of the global platform



A timeline of the four industrial revolutions

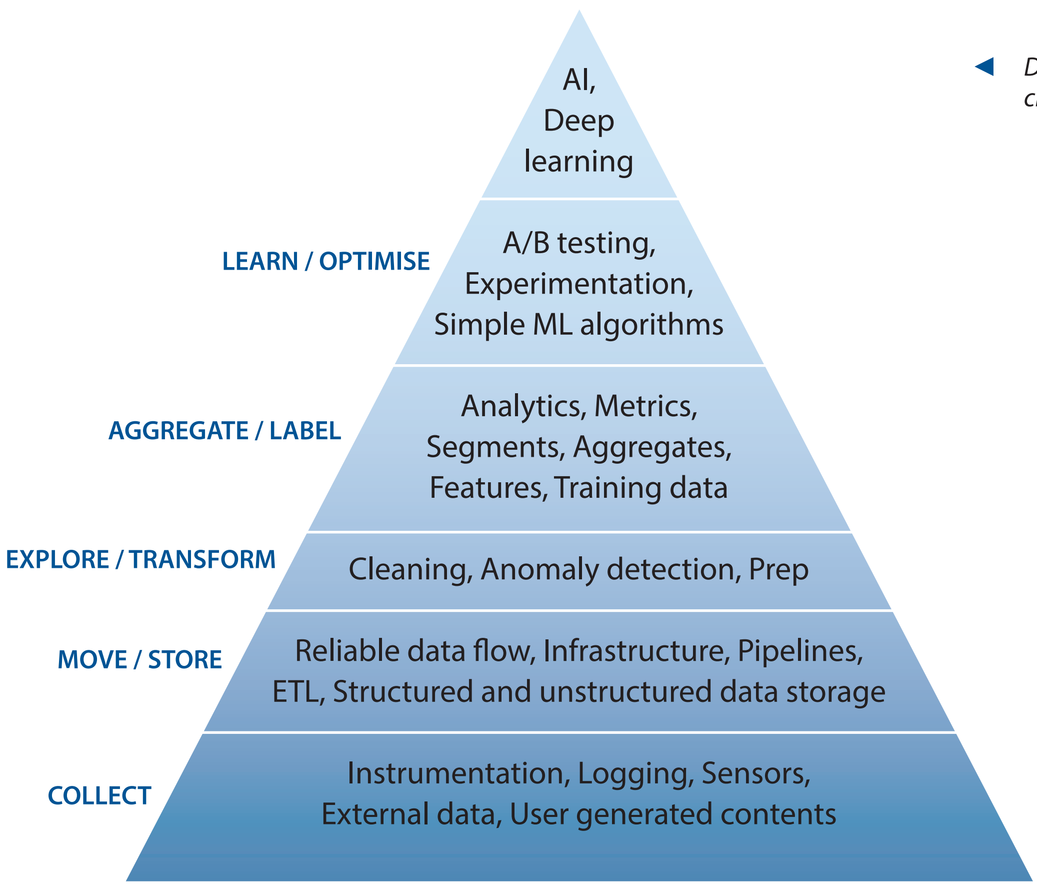


Diagram 1. The data science hierarchy of needs.

Industrial automation and IIoT engineers are pioneers in the Fourth Industrial Revolution.

solutions. An example of this is the Siemens Mindsphere cloud service, which runs on AWS. For security reasons, the database may also be located on the production site's own server. In such cases, however, many benefits of a cloud-based solution are lost.

Function optimisation and data structuring

Stored information can be structured or unstructured. Data analysis experts structure data and remove irrelevant elements (so-called noise) from data in databases.

Process or process support functions such as maintenance are optimised in collaboration with the customer by monitoring sensor values (pressure, temperature, vibration, humidity, etc.), iterating production control parameters, and measuring KPIs (Key Performance Indicators) based on the parameters analysed and the resultant corrective measures taken. If a digital twin of the process control system with a real time production data connection is available, it can be used to test the proposed corrective measures. The goal is to create value for owners by streamlining process operations, proactive maintenance and minimising production waste.

The duration of this step varies from case to case, sometimes it can take several years. This gives the automation supplier the opportunity to create mutual business benefits for itself and the customer, for example, by integrating a lifecycle management service into its production development program.

Visualisation tools

There are many different options available on the market for visualising the results of analyses and process optimisations, such as Microsoft's flagship product MS PowerBI. Many automation system vendors also offer visualisation packages with their system delivery and cloud service concept. Siemens offers the Tableau visualisation tool, for example, with its Mindsphere cloud platform. Open source platform-independent visualisation tools such as Grafana, however, also provide a competitive alternative.

Machine learning and robotics

With an extensive partner network and university collaboration, industrial automation suppliers can finally rise to the top of the information needs pyramid. Based on what is learned at the lower levels, advanced analytics and mathematical algorithms are developed that model and predict the process. Based on this "intelligence", the program suggests process improvements and can also implement them – this is machine learning.

Advanced robotics complements the whole system by pushing the degree of production automation even higher, both in the production itself and its supporting functions.

Autonomous factory

With increasing computing power, the ever-evolving realm of application options adds another dimension to the digitalisation of industrial automation. For example, the integration capabilities of proactive maintenance with augmented reality and machine learning production control systems inevitably create the image of an autonomous factory. In addition to actual production processes, an autonomous factory maintains and optimises itself, its material inventories, and delivers production reports to its owners.

Early warnings of technical malfunctions are provided, after which the installer can take remedial action by completing an inspection tour of the production facility's digital twin with real-time information associated with each device.

Summary

Industrial automation and IIoT engineers are pioneers in the Fourth Industrial Revolution. It will be remembered as one of the most significant periods in the history of industrialisation and society. The ongoing digital breakthrough in industrialisation will be the largest of its kind.

About the author

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Markus Havupalo has extensive experience in managing, planning and implementing customer-oriented automation and IT projects from detailed design to plant commissioning. His work is mainly focused on food/process industry and marine industry projects. He joined Elomatic in 2005 and currently works as Design Manager for the Automation and IIOT & MES Team in Turku. He also manages strategic development projects to develop Elomatic's design practices and tools.

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Digital security in

Vulnerabilities in industrial control systems

Text: Juhani Kääriänen

industry

Picture © depositphotos/welcomia

With the digital revolution in society, security concerns are becoming increasingly prominent. Digitalisation remains, however, an opportunity above all else. This article briefly introduces Digital Security Theory and presents SAFESCAN, a digital security vulnerability assessment process that can identify vulnerabilities in industrial control systems (ICS).

Digital security can increase the availability of industrial automation equipment. In addition, data integrity (data is unchanged) and confidentiality are considered. In ICS systems, availability is paramount. Other security attributes include non-repudiation (proven imprint) and authentication (identity verification). Other basic concepts are threats, risk and vulnerability.

A threat can infiltrate a system with a particular risk. The threat can be an internal or external threat to the company and, for example, vandalism, crime, espionage, terrorism or war. The vulnerability could be caused by people, company processes, or the technology used. In all cases, the risk remains (residual risk), but the company should assess whether the residual risk is acceptable. The risk may be related, among others, to value or reputation. The risk can also be insured as needed to reduce the risk to value, but the residual risk to reputation is more difficult to deal with.

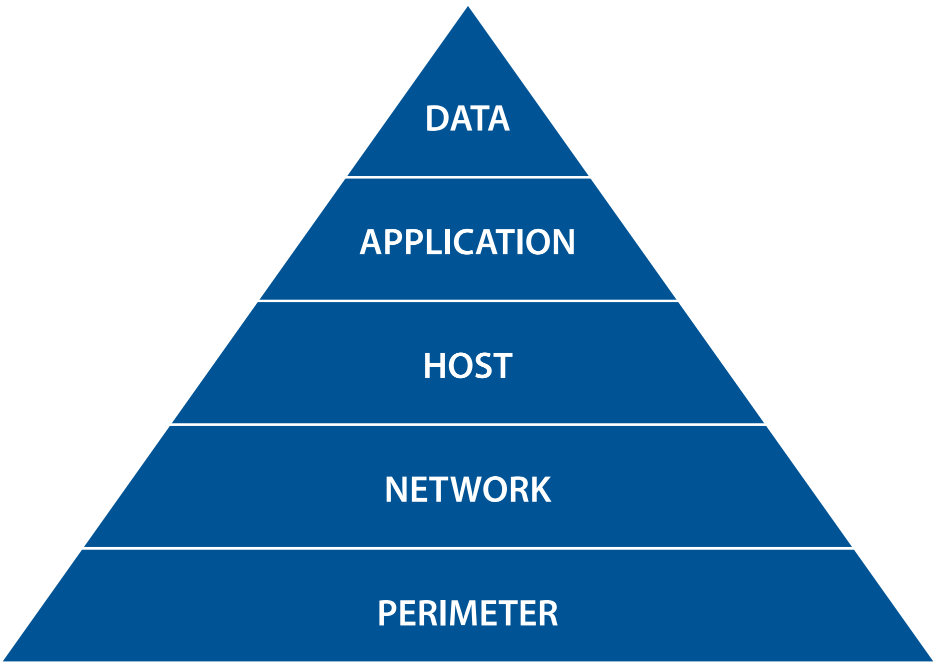
Differences between IT and ICS systems

There are many differences between information technology (IT) and ICS system security and how they are defined. For this reason, it is important that ICS security is defined by a

Picture © depositphotos/genkur

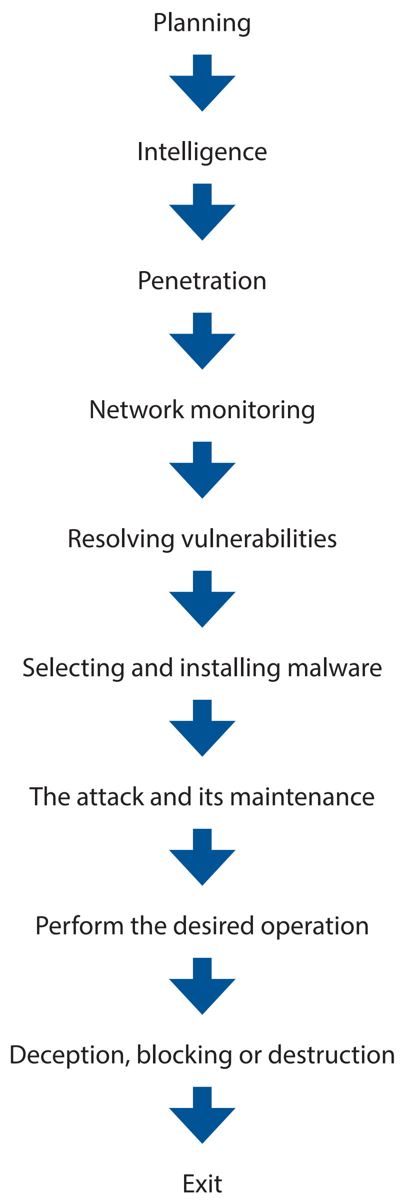
Category	IT	Automation (ICS)
Performance	Does not necessarily have to be a real-time response	Response needs to be rapid
Availability	Booting is possible	System needs to be constantly available
Risk Management	The correctness and reliability of data is the most important	Personal and environmental safety is the most important
"Man – Machine" interaction	Interaction between man and machine is less critical	Access to devices must be limited, but usability must be good

Table 1. Examples of differences between ICS and IT systems.



Security layers in automation systems

Digital security can increase the availability of industrial automation equipment.



▲ *Typical steps in a cyber attack*

specialist. The person should have know-how of electrical, instrumentation and automation equipment.

Digital security also involves the relationship of the digital device to the physical environment; among others, the location and locking of automation cabinets. However, it must be remembered that the most important security attribute in ICS security is availability, i.e. usability. It may not be possible to lock lockers or devices with locks or passwords if the availability requirement is high. Table 1 lists some of the differences between IT and ICS systems.

Security layers of the automation system

Layering should be taken into account in system structure design as it reduces the risk of a successful attack. The automation system is usually isolated from the IT network, for example, with the use of a firewall or demilitarised zone (DMZ). In this case, the connection to the automation network is limited. Systems can often also be accessed remotely via a virtual private network (VPN).

Remote connectivity solutions are provided by various device vendors. In digital security, interfaces pose the greatest risk. Automation systems can be divided into different layers, the outermost layer being the periphery of the network and the innermost level being the data in computers and in the network. The data may be in use, in motion, or stored (stationary). Digital security solutions can be created at these various levels, such as a DMZ or IDS (Intrusion Detection System).

Lifecycle solutions

Digital security must consider human, organisational process and technology aspects. Networking and cooperation between the various players, as well as ongoing developments must also be considered. Networking enables the transfer of data and thus the improvement of situation awareness. Situation awareness is crucial in the event of an attack, or while preparing for an attack that is still preventable. Continuous development is also important because digital security is a highly dynamic area and hackers always strive to stay one step ahead.

In its most comprehensive form, digital security creates a lifecycle model. The lifecycle solution proceeds in stages: definition, analysis, design, implementation, review and continuous development. A lifecycle solution enables better resilience, whereby ICS security is maintained as a stand-alone process among other company processes.

Progress of an attack

An attack can be divided into four phases. The first phase is targeting, where the attacker develops situation awareness.

People, Processes, Technology					
Management	*Malfunctions*	*Situation awareness*	*Defence*	*Recovery*	*Maintenance reliability*
■ Management	■ Training ■ Protection ■ Auditing ■ Malfunction management ■ Simulation, Red / Blue Team ■ Business continuation	■ Detection ■ Information sharing ■ Situation awareness	■ Restricting ■ Defence ■ Counter measures ■ Communication	■ Recovery ■ Communication ■ Learning	■ Material ■ Functional
Cooperation Continuous development					

▲ *Table 2. Attack handling from the target's perspective*

SAFESCAN in a nutshell

- Promotes digital security development projects, including administrative aspects
- Provides an outside perspective on security matters
- Provides expertise in ICS systems
- Provides control measures to reduce vulnerabilities
- Reduces the risk of a successful attack and subsequent environmental losses, business losses or reputational losses
- Periodic repetition of the analysis allows for continuous improvement
- Scalable solution suitable also for SMEs
- Applicable standards: *FIPS-200-final-march (FIPS-PUB-199-final, NIST sp800-53-rev2-final), **NIST special publication 800-18r1

*) Federal Information Processing Standards
**) National Institute of Standards and Technology

SAFESCAN looks for vulnerabilities in ICS systems and associated risks.

The next step is to perform a target analysis, which involves situational understanding. The third phase involves selecting the target and the attack method. In the last phase, the attack is carried out. After the attack, one can return to step 1 and execute a new attack based on the new situation awareness.

Attacks can be carried out in parallel, quickly disrupting multiple targets at the same time. The goal is to strategically paralyse the target. In this case, it is difficult for the party being attacked to develop good situation awareness and to systematically defend itself to avoid damage. Attacks sometimes only last a few minutes but can take years to prepare. In this case, it is important to detect potential reconnaissance operations against the company before the attack.

SAFESCAN digital security vulnerability assessment process

SAFESCAN is a digital security vulnerability assessment process developed by Elomatic, which looks for vulnerabilities in an ICS system and associated risks. The process is subject to standards developed by the NIST Agency. The output of the process is a list of vulnerabilities and operations that should be performed to further improve the digital security of the system.

With SAFESCAN, one can easily and cost-effectively assess the vulnerabilities of an industrial automation system. At the beginning of the survey, the consultant becomes familiar with the customer's automation system. The automation system is subdivided into parts, and these parts are examined from a digital security viewpoint by scoring the risk of each part by attribute.

The SAFESCAN product divides the automation system into five different levels. Solutions have been defined at the different levels to enhance the digital security of the system. Each of these levels creates a barrier for hackers and makes it harder to gain access. SAFESCAN is designed to prevent disruptions but is also prepared for disruptions and the need to restore business operations.

When investigating vulnerabilities, the customer's staff is consulted. The discussions are preceded by training on the basics of digital security. After the training, discussions are conducted separately in small groups or between two persons. The discussions aim to maximise interaction in order to detect vulnerabilities.

At this stage, the discussions do not aim to identify solutions but to find out how digital security is dealt with in the company. Generally, the idea is to find out how the staff work and whether they have any suggestions for improvement.

Following the discussions, a summary and table showing the current vulnerability profile of the ICS system is prepared. Based on the vulnerability profile, control measures are proposed to improve digital security. In addition, a vulnerability profile is created after the control measures. This profile shows the impact on digital security (risk) if the proposed control measures are performed. Finally, a list of control measures that should be taken is drawn up.

A SAFESCAN analysis can also be performed periodically to check for new vulnerabilities and to make corrections to the risks identified in the previous inventory. This keeps the digital security of the target's ICS system up to date.

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Juhani Kääriäinen holds a graduate degree in process automation from the Oulu University. After graduating in 2000, he has worked in research and training as well as in consulting and engineering. He also has several years' experience in sales and marketing. Currently, Juhani works at the Elomatic Jyväskylä office as Consulting & Sales Manager.

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Simulation of deflagration in exhaust systems

An application of CFD in safety engineering

Text: Bingzhi Li

Computational Fluid Dynamics (CFD) is being increasingly used in safety engineering to simulate toxic gas dispersion, fires, and explosions. Experimental studies in this area are dangerous, difficult, and expensive. They are also often confined to a relatively small scale compared with practical situations such as fires in chemical plants and explosions in coal mine tunnels.

Empirical approaches can also be found in different safety codes. They are used to assess the risk and the effects and consequences of accidents. CFD numerically solves the governing equations of fluid flows, which can involve heat transfer and chemical reactions, to predict the flow field. It is a powerful tool which, in addition to the valuable experimental studies and the empirical approaches, can provide data for the effects and consequences of specific accident scenarios, enhance the understanding of possible scenarios, and provide insights into mitigation measures.

◄ *Fire at a refinery outside Puerto Rico's capital San Juan, Friday, 23 October 2009 (BBC, 2009)*

Ensuring the adequacy of CFD simulation

While the reliability and the accuracy of CFD simulations is still a significant concern, CFD codes have been approved as a tool in the area of safety analysis. There have also been efforts in ensuring the adequacy of CFD simulation in safety engineering.

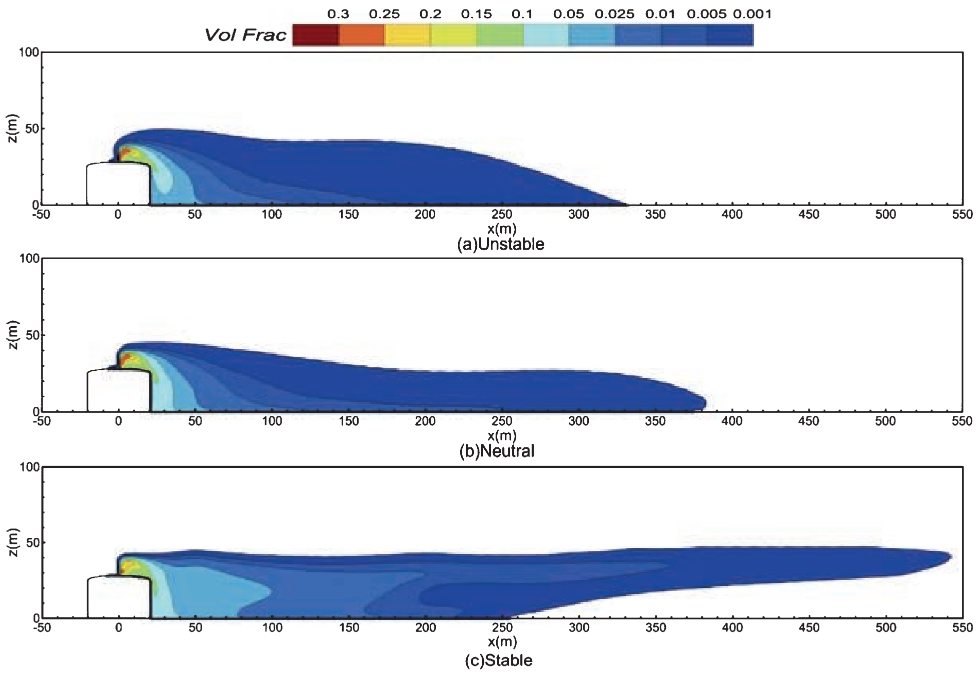
PHMSA (Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation) has approved a software programme for radiant heat flux and four software programmes for atmospheric vapour dispersion for the purpose of determining the extent of LNG exclusion zones. Exclusion zones are established to protect the public from the potential consequences of the unintentional release of LNG (PHMSA, 2017). In 2006, the Idaho National Laboratory prepared "Processes and Procedures for Application of CFD to Nuclear Reactor Safety Analysis" for the U.S. Department of Energy (Johnson, et al., 2006).

In the EU SUSANA project (SUpport to SAfety aNAlysis of Hydrogen and Fuel Cell Technologies) (FCH, 2017), which concluded in 2016, a model evaluation protocol was developed to support the use of CFD analysis in safety engineering in relation to hydrogen and fuel cell technologies. It was emphasised that the following two aspects need to be addressed to apply CFD with a high level of confidence in the accuracy of the simulation results:

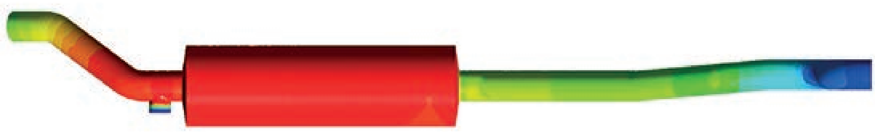
1. the capability of the CFD models to accurately describe the relevant physical phenomena
2. the capability of the CFD users to follow the correct modelling strategy.

Explosion risk in dual-fuel engine exhaust systems

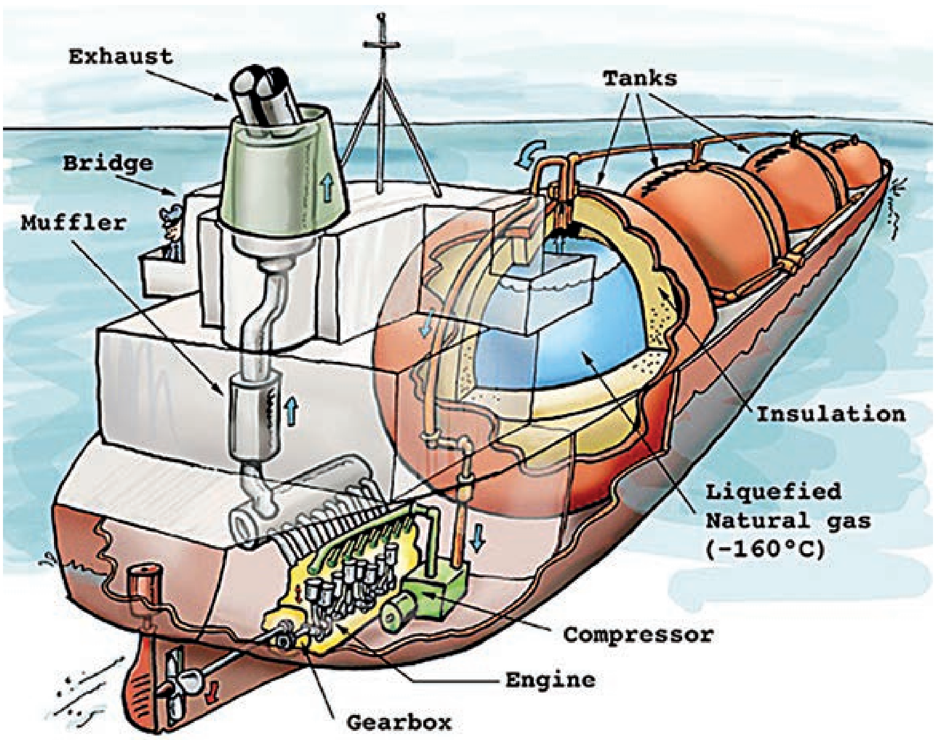
A dual-fuel engine can run on both liquid fuel (e.g., heavy fuel oil) and gaseous fuel (currently mainly natural gas). Since the combustion of gas leads to significantly lower emissions, the application of dual-fuel engines for marine purposes has been driven by more stringent emission regulations. Dual-fuel engines can also reduce the



Simulation of the dispersion of LNG vapour released from the top of a storage tank under the effect of different atmospheric stratifications. Unstable, neutral and stable, 180 s from the start. The vertical concentration contours of LNG cloud at the downwind axis. (Guo, Zhao, Wang, Yao, & Hu, 2019).



Pressure development during a deflagration simulation.



Cutaway illustration of an LNG carrier (Welleman, 2004). Boil off gas from the LNG tanks is used in the engine for propulsion.

CFD is increasingly used in safety engineering to simulate toxic gas dispersion, fires, and explosions.

requirement for extra fuel storage on vessels and help improve efficiency, especially for LNG carriers.

On marine vessels, the exhaust system of a dual-fuel engine typically consists of an exhaust pipe, a ventilation system, and one or more silencers. It may also include a boiler for waste heat recovery and an SCR reactor for NOx reduction, as well as a by-pass line for this equipment.

When an engine runs on gas, there is a risk of unburnt gas entering the exhaust system even though preventive measures are taken. If the gas-air mixture ignites, deflagration will occur and lead to a rapid increase in temperature and pressure inside the exhaust system. This would create an explosion hazard for the equipment and the personnel on board and mitigating measures would have to be taken.

For example, the DNV GL classification rules for ships with gas-fuelled engines require suitably designed and fitted explosion relief systems, unless the exhaust systems are designed to withstand the worst-case overpressure resulting from ignited gas leaks (DNV-GL, 2017). Both one-off rupture discs and reclosable spring-loaded valves can be used.

The arrangement of the pressure relief system, i.e., the number, size, and position of the pressure relief devices, should already be considered in the design of the exhaust system. CFD simulation is a cost-efficient way of evaluating the arrangement of pressure relief devices and to ensure class approval.

Simulation of deflagration in exhaust systems

In order to evaluate the arrangement of pressure relief devices, simulations of deflagration in exhaust systems must be carried out in reasonable gas leak scenarios. In a conservative approach, the worst-case scenario could be included, in which none of the engine cylinders is firing but gas is still being supplied to the engine. In such a case, the gas-air mixture would enter and fill a large part of or the whole exhaust system.

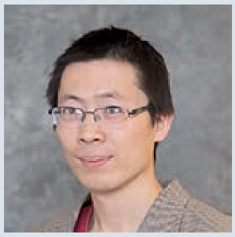
The worst-case scenario is somewhat theoretical, and the probability of it occurring is low. However, if the simulation shows that the pressure relief arrangement can help prevent excess pressure in the worst-case scenario, the arrangement should be sufficient in normal conditions. Less severe but more plausible scenarios could also be included.

Adequate details of the equipment, e.g., silencer, should be included in the simulation model to represent the equipment characteristics. In the simulation, a rupture disc should open and release pressure when its burst threshold has been reached, while the size of the opening of a spring-loaded valve depends on the loaded pressure and its design properties.

Transient 3D simulation should be performed so that the propagation of the reaction zones of the gas-air mixture and the pressure waves can be investigated. During the simulation, the pressure history in any part of the exhaust system can be recorded, and the maximum pressures obtained. The maximum pressure can be compared with the pressure limit of the equipment.

A simulation of deflagration in exhaust systems should provide a validation of the arrangement of the pressure relief devices or produce results that can be used to improve the arrangement, e.g., to suggest new positions for the pressure relief devices.

About the author



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Drawingless production in digital data-driven shipbuilding

Text: Ludmila Seppälä

Can 3D models replace traditional design drawings? If the question were formulated like this, most people would answer in the affirmative. Several would question whether it has not already been achieved and, if not, that it was only a matter of time.

If the answer to this question is that straightforward and such an obvious direction for the development, one can only wonder why this change has not happened already. 3D models have been around in shipbuilding for almost 50 years. Has this not been enough time to polish the technology and replace old artefacts, such as 2D drawings?

This article shows that the answer is not that simple and does not depend exclusively on technological aspects.

The power of creative destruction and Kondratieff's waves theory

Kondratieff's waves theory provides a broad structured view of the history of technological development. Based on the financial data from rolling 10-year returns of Standard & Poor's top 500 companies, spikes or waves can be observed that match technological changes. Figure 1 presents these waves along a timeline. Behind every significant upswing in financial returns, which moved societal development forward, there is a considerable step in the use of new technology: steam engines, railways, electricity, automobiles and petrochemicals, and information technology. None of the technologies is an isolated innovation or achievement: it is something that society was able to adapt and use profitably. Technological breakthroughs are tightly linked to societal development in terms of adaptation and acceptance.

According to Kondratieff's theory, the next and sixth wave of creative destruction will be fueled by intelligent technologies. There are many ongoing discussions in industry about digitalisation, digital transformation and digital manufacturing, industry 4.0 and smart factories, as well as AI and the use of digital twins in production.

Intelligence is a key aspect of the sixth wave and differentiates it from its predecessor, which was based on information technology. One can speculate whether intelligence means actual AI or the possibility to be not only digital, but also data-driven.

One practical example of this change is the ongoing development of digital twins. As elaborated by Cabos and Rostok (2018), a digital twin is a digital representation of an object, enriched with behavioral models and configurations or conditions. As Hafver, Eldevik and Pedersen (2018) point out, the novelty of digital twins is not the existence and use of 3D models as assets, but how these models are bundled.

In other words, it is not about IT anymore; it is not about the possibility to digitalise all data and the 3D model, but about the intelligence behind this data.

Deep transitions theory and evolution of CAD as innovation

According to the theory of deep transitions developed by Schot and Kanger (2018), there are more details inside each wave as it can be split more accurately into approximately 50-year cycles. An interesting result can be observed if this theory is applied to changes in shipbuilding. Figure 2 illustrates the main technological changes and innovations concerning deep transitions.

The era of IT in shipbuilding aligns with the beginning of commercialised use of CAD systems. Triggered by IT advancements, CAD evolved in the early 1970s from an innovation into something that became a common and essential part of shipbuilding projects. It took about 50 years for the technology to mature, for the newest hardware to be taken into use and for it to be fully accepted practice. In turn, the increased accuracy of design allowed even larger and more complex projects to be handled, a development that took shipbuilding to an entirely new level. The innovation served the industry and changed it. It was, however, not an isolated phenomenon. It was made possible by societal developments that required a large number of cargo ships and other types of vessels for global trade. As such, the context of innovation plays an essential role in the transition.

Multi-level perspective – innovations in context

The Multi-Level Perspective (MLP) framework is useful in understanding how a transition occurs and what makes it possible for an innovation to become viable and widely used.

The multi-level perspective approach was originally developed by Frank Geels to explain socio-technological

Figure 1. Kondratieff (1935) waves: linking rolling 10-year returns on the S&P top 500 and technological disruptions.

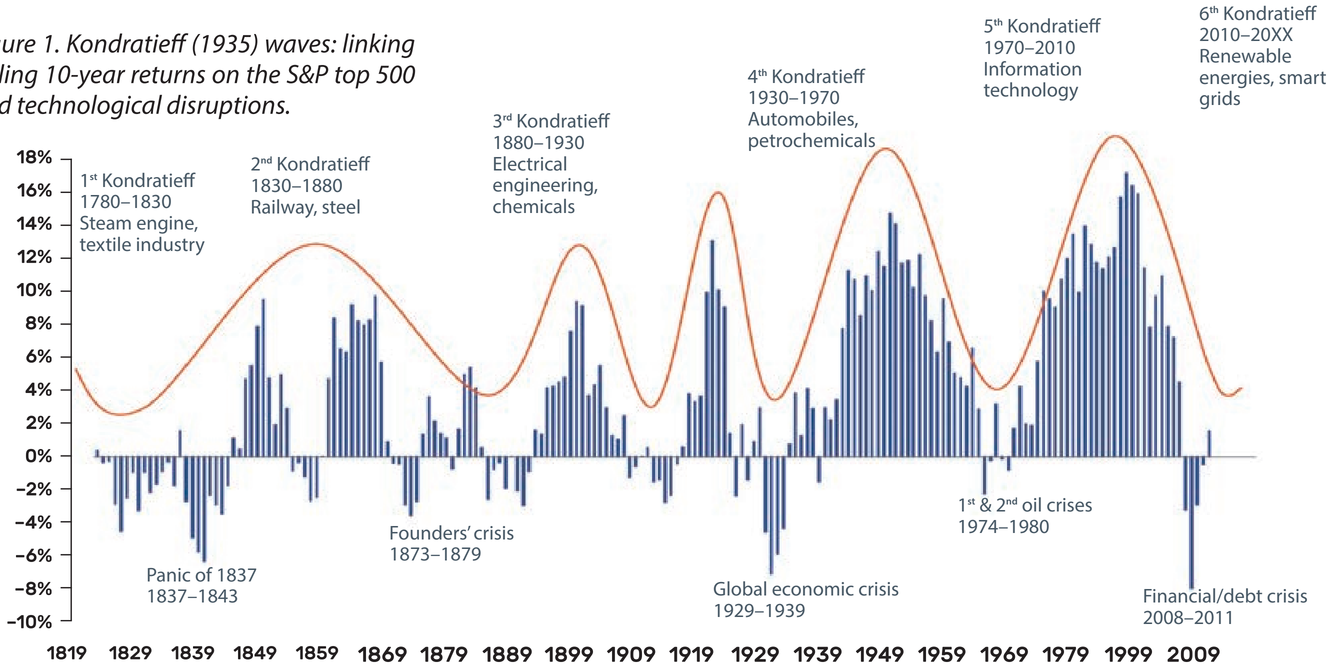
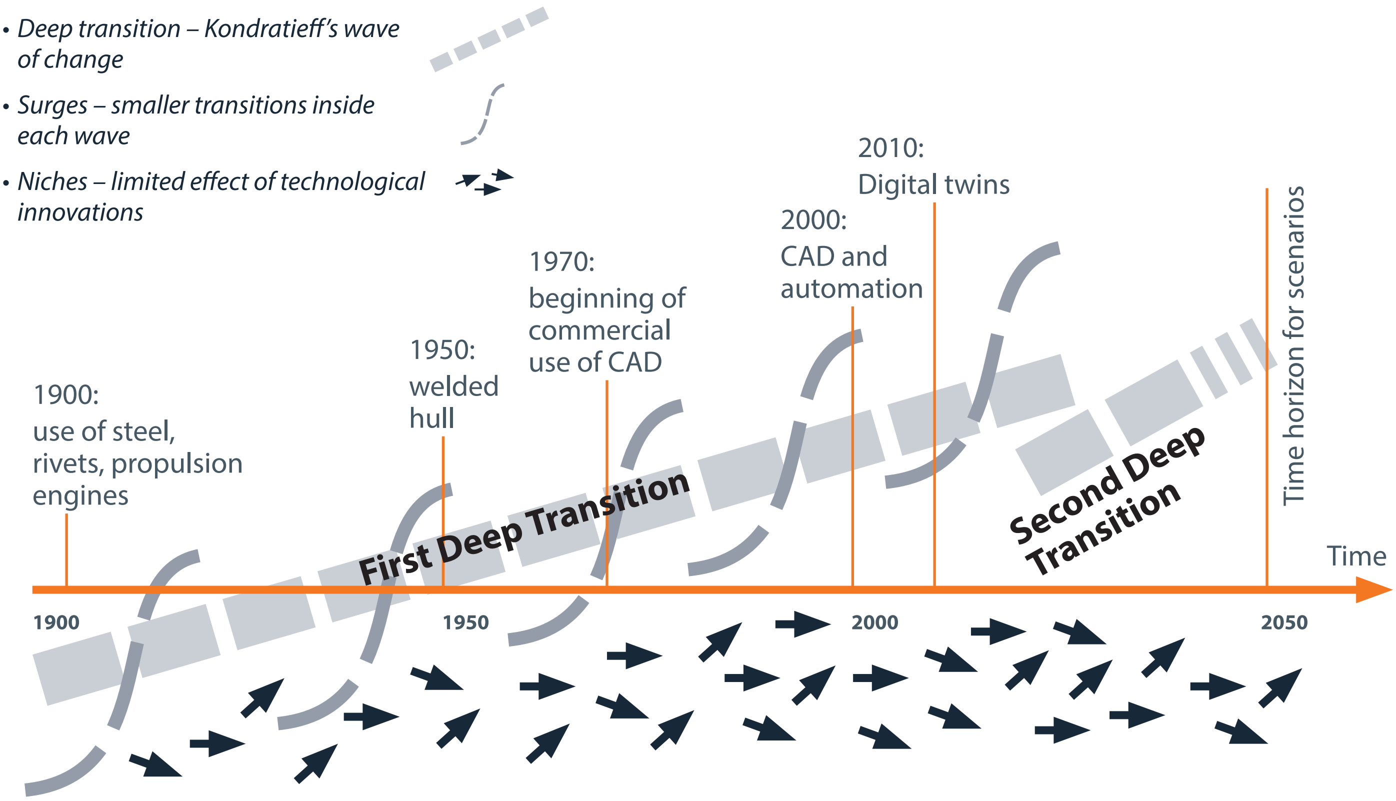


Figure 2. Deep transition transformation and historical shipbuilding milestones, including CAD development.



transitions, with a focus on sustainability. It presents a transition process in the context of three main layers: landscape, regime, and niche.

The landscape layer represents the most stable structure – the existing state of things; it is a mixture of the political and economic landscape, the historically and socially stable way of doing things, and time-proofed technology that has been in use for a long time. The regime layer is more dynamic and consists of existing practices and the ways of process organisation. Niches are the most dynamic places for incubation of new ideas and practices. Presumably, niches appear and frequently disappear, often having little

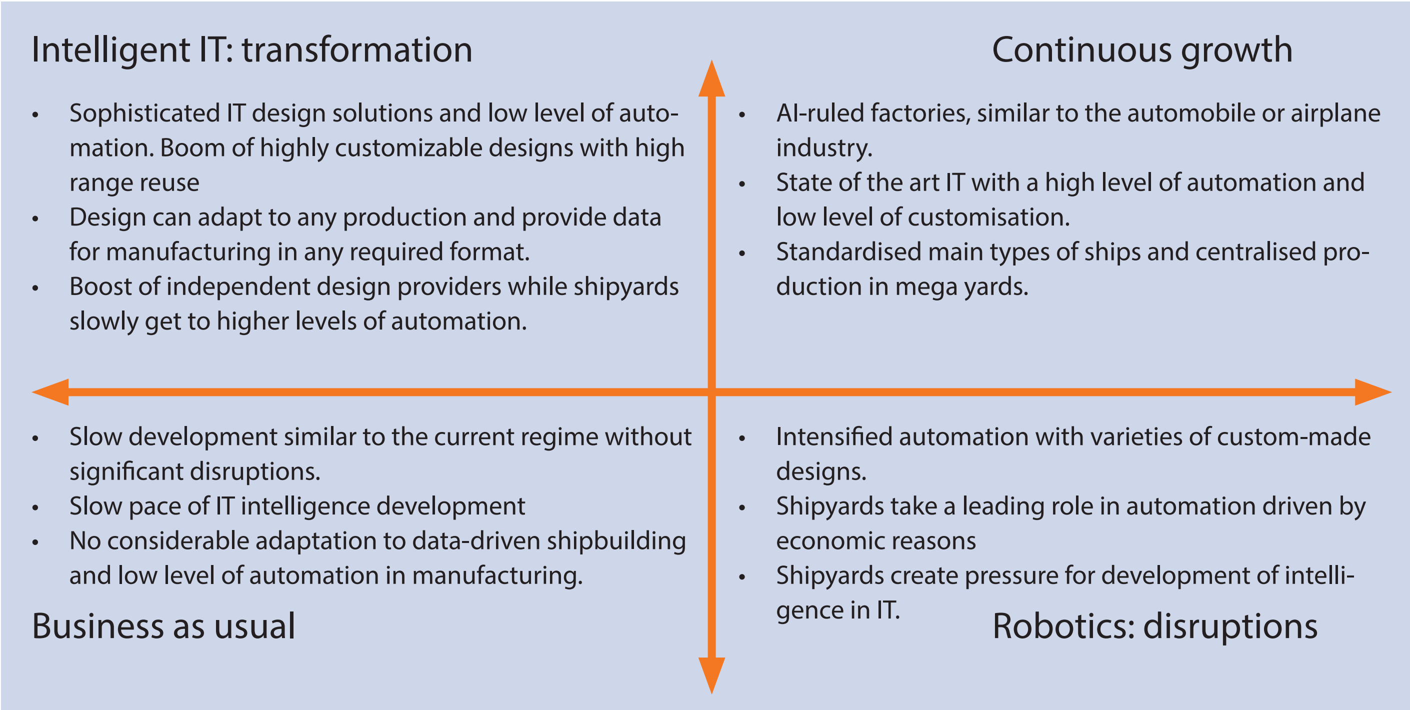


Figure 3. Future scenarios of drawingless production in digital and data-driven shipbuilding towards 2050.

impact on the system. However, when there is pressure from the landscape, the regime level has cracks and openings, creating space for the niche to enter the regime level and reshape it. "Niche-innovations may break through more widely if external landscape developments create pressures on the regime that lead to cracks, tensions and windows of opportunity" (Geels, 2010).

The tension, caused by globalisation and the development of IT technologies, such as increased computing power and graphics cards, created a "window of opportunity" and allowed CAD to progress to regime and landscape levels. A side effect of the transition was that CAD providers became significant players in the maritime industry.

Next wave of intelligent technologies

The intelligence of IT allows the provision of data in digital format that is suitable for production. For example, based on the data collected by CADMATIC, when the first 3D viewer, eBrowser, was introduced on the market in 2000, the direct estimation from shipyards was that they were able to reduce the number of drawings needed for production by 30%. The 3D model became accessible not only to CAD users – typically designers in the office – but also to production staff. It also did not require any special skills or training to use. It provided a powerful push to reduce the number of drawings. However, there are still cases when the amount and types of production drawings are justified by tradition and processes at a shipyard, and less by the practical need for these drawings in production.

Following this development, after introducing CADMATIC's eShare as a central portal for all interlinked project information, a further reduction of 70% of drawings was achieved. This is only one example where increased intelligence in IT technology significantly affected the number and types of drawings involved in production but was capped by societal readiness to change the existing regime. Pioneering yards, focused on innovation and effectiveness, were more ready to make the change than yards where tradition and maintaining the status quo were stronger driving forces. The human and societal factors conflict with technological possibilities in this case.

The level of automation is a key dimension in the discussion about automated production. There are many possibilities to automate production: steel cutting and bending, welding robotics, 3D printing, and automatic adjustments for workshop flows based on data analysis. Together with developments in robotics, this has become an essential factor for ship manufacturing. The cost of machinery and implementation has been a holding element in this regard.

The future of drawingless production

Figure 3 illustrates four main possible scenarios for the future of drawingless production. They are based on a division of high to low levels of IT

It is not about the IT anymore, but about the intelligence behind the data.

intelligence and automation. Two stereotypical scenarios present "business as usual" and "high hopes for change" possibilities. The other two illustrate conflicting trends and tensions in the landscape that provide opportunities for innovations to grow.

While all four scenarios are possible, the continuous growth scenario is perhaps preferable, if one wants to be optimistic and disregard natural developmental limitations. A combination of scenarios for transformation and robotics would present a somewhat realistic picture in the medium-long perspective. In both cases, the gradual elimination of drawings in the production process is a likely outcome.

Considering the main driver of intelligent IT, drawings are already being gradually substituted with 3D viewers and with direct data transfer to production or manufacturing control systems. CAD plays a key role in the substitution process by providing interactivity with data and faster access to it within change management.

Originally, input to CAD was provided by users. This is slowly changing, however, towards the use of embedded design rules and the substitution of direct parameter inputs with inputs based on analysis or AI.

Interaction with data distinctively differentiates the digital era. The first attempts to standardise drawings aimed to improve readability and production quality. For the data-native generation, this poses unnatural limitations. Instead of a static snapshot, people prefer to obtain data on demand, and then manipulate it.

The following use case illustrates this process. Traditionally, many drawings in shipbuilding come from piping production data or spool drawings. Estimations are that a big cruise liner, of about 350 m, has about 10,000 spools. With current practices, these drawings are automatically generated and annotated. However, about 5% (with effective use of CAD and settings matching production needs) require manual work.

The process itself is quite laborious and time-consuming. However, the main culprit is the use of these drawings in production. Every drawing must be manually examined and used as an instruction to manufacture a piece of pipe and often the data provided on the drawing is not sufficient or outdated due to changes in design by the time it reaches the workshop. The possibility to generate and visualise production data at any time would remove the disconnect between design and manufacturing.

As a practical example of such developments, some CADMATIC customers already use provide an online connection to design data in the production workshop and display the data in 3D viewers with annotated models. Alternatively, they use AR with HoloLens or VR interfaces directly with the 3D model.

The foundational technologies for drawingless production are set and the direction is well-defined. The question remains whether the window of tension is enough for the innovations to progress, spread and become part of the regime.

This article is a shortened version of a paper presented at COMPIT2019.

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Enterprise Production Management and digitalisation of upper level automation

Text: Jussi Soininen

With the industrial Internet of Things (IoT), the management of production and related production infrastructure are moving to a new level. Digital service products are becoming more common and will provide owners and users with a higher degree of control and more accurate product development information.

Nowadays, it is technically quite easy to gather information from production processes. In some cases, information bloating has even stopped development. Sometimes, it is necessary to ask to what and how the information should be applied. Knowledge should not be added for the sake of knowledge, but to benefit the owners and users of the knowledge.

Standardised and well-established content and functionalities make production easier. There is no need to reinvent the wheel. Traditionally, system and software vendors have sought to standardise data processing. Copying previously developed data processing systems is profitable for the vendor, because high-volume products are inexpensive for end-users and the system has good lifecycle control.

However, well-established solutions are not enough in the long run. To produce a competitive advantage in industrial production, Manufacturing Execution System (MES) applications must also have unique features. MES applications must also take the specific characteristics of the enterprise's production into account.

Knowledge is not enough, understanding is not enough – progress and success require greater levels of intelligence and wisdom. Therefore, MES-level applications that utilise standardised modularity must be flexible and upgradeable to meet future change needs.

Traditionally, IT departments in industry have kept systems for 10 or even more than 20 years, until it becomes necessary to switch to a new one, often for purely technological reasons. For example, due to cost reasons, the system may not have been better adapted to changing circumstances and operating practices.

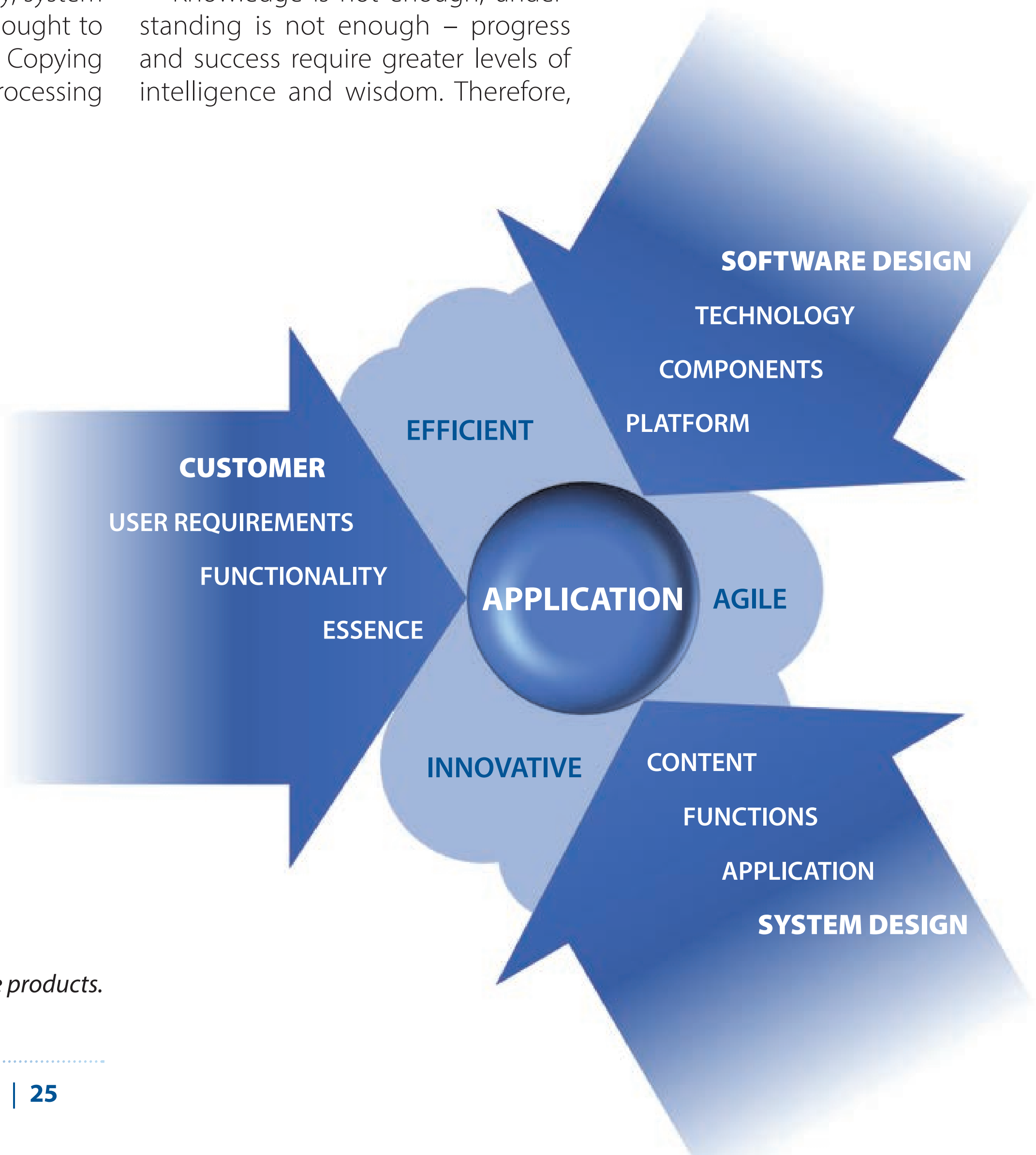


Figure 1. Development of service products.

The focus is now shifting to computing and visualising smarter statistics, event correlations and predictions.

Service product development

An example of good service product realisation is the optimal embedding of system engineering and IT technology that meets the customer's needs (See Figure 1). Modular solutions produced for today's application platform can be customised and developed by configuring new data sources, data structures, cross-structure relationships, and user interface components. The typical characteristics are:

- Openness to the owner
- High availability
- Agile adaptability
- Easy controllability

Service product production is moving towards closer cooperation with the customer. This is essential for agile configuration of application solutions and application templates to meet the needs of the customer. It is imperative to listen to and understand the customer's user requirements, see potential future changes, and know the reality of the application, both at a conceptual level and in practice.

Service collaboration with the customer also means providing application solutions with greater openness so that the customer has a real opportunity to choose how much and how deeply he wants to manage the application development across its life cycle, including at the executive level. This means, for example, that the customer can choose whether to make changes to the application's interface or get help from the application vendor.

It is the supplier's responsibility in this collaboration to bring new, modular technological solutions for a heterogeneous field of data sources, for intelligent production control, for deep data analytics, and for virtual visualisation.

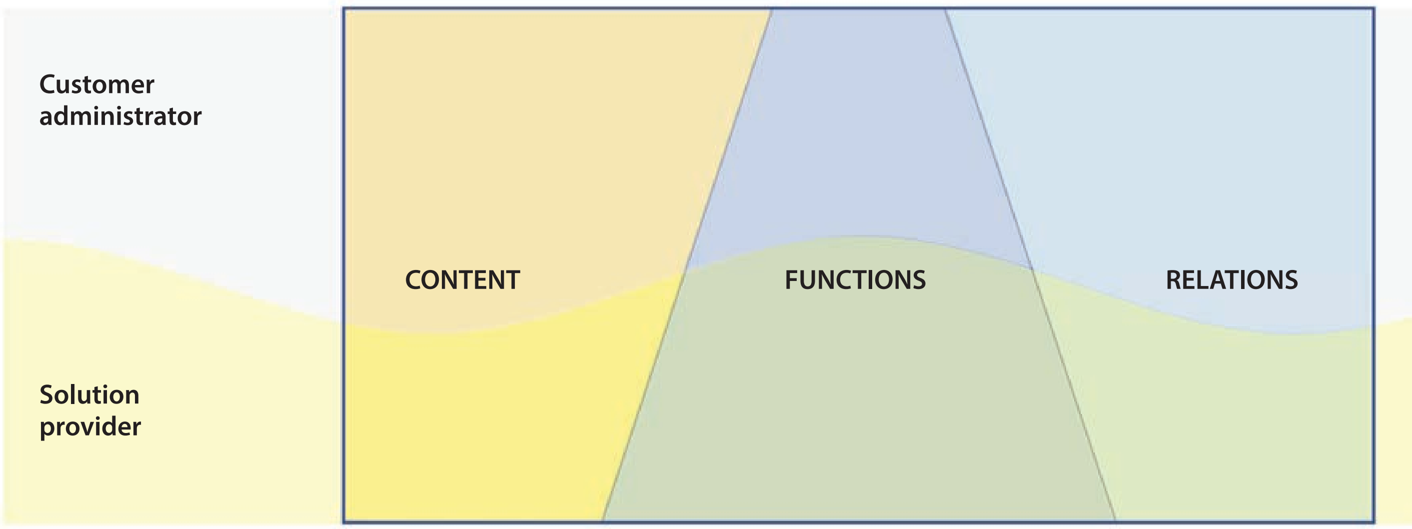
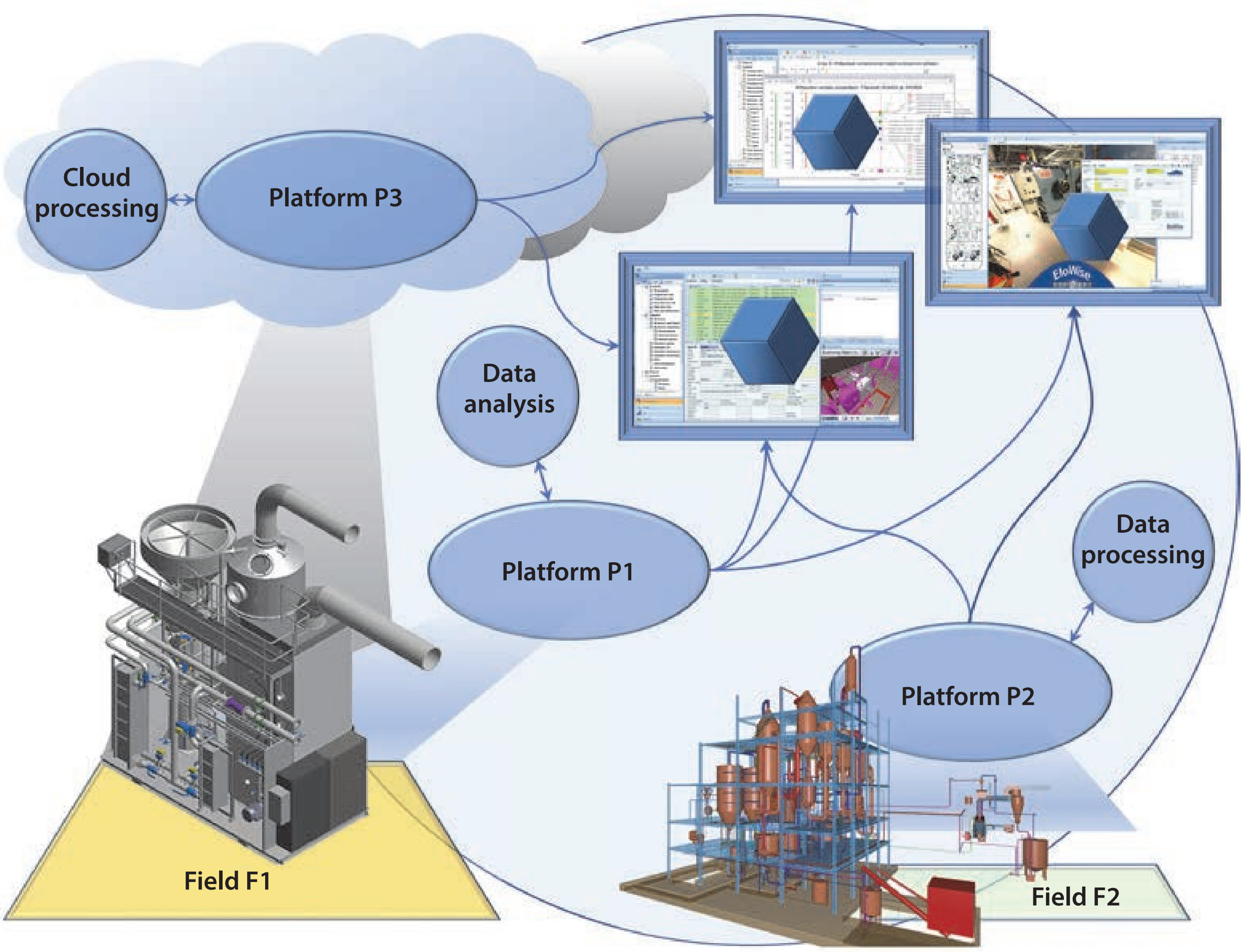


Figure 2. Cooperation with the customer.

Figure 3. IOT – The connector of IT multiculturalism.



Case EloWise

EloWise is an example of an application platform that is an agile and adaptable MES level solution. With the help of well-established connection technologies, the system can connect field data sources to a data acquisition interface, structure, and further process data for use at higher levels. Various analysis tools and calculation routines can be integrated into the system. The UI structures are fully configurable.

In addition to integrating the entire existing production field and the existing data processing platforms, it is necessary to ensure that the need to add field sensors and technical computing tools can be easily integrated into the system. Implemented with EloWise principles, the system integrates field interfaces into an application-specific relational database which provides the further-processed information with associated computing components. The configuration database also serves to provide an optimal user interface for the user experience.

When creating a digital twin of an industrial process, it is not enough to only collect a huge amount of information. The structural, relational, and functional simulation model must be able not only to serve maintenance and product development, but also to function as a real twin's assistant and supervisor. Therefore, it is imperative to develop innovative, efficient, and agile AI-assisted tool components for the model to gradually become a closer reflection of reality.

Table 1. Levels of information processing in data processing.

Wisdom level	The system has the ability to support creativity ■ by supporting the emergence of innovation ■ by supporting the implementation of measures resulting from innovation
Intelligence level	The system has the ability to produce ■ derived information from the information content and its interdependencies ■ meaningful and appropriate solutions
Understanding level	The system is capable of compressing information into a more concise form and recognizing the meaning of information and information relationships
Knowledge level	The system is capable of collecting and compiling data into a usable form and state

Impact of industrial IOT on MES application production

Today's industrial production units have dozens of separate systems linked to production infrastructure that produce information for a specific task and use. The systems may be very discrete and independent, at least in terms of information utilisation, due to different vendor interests.

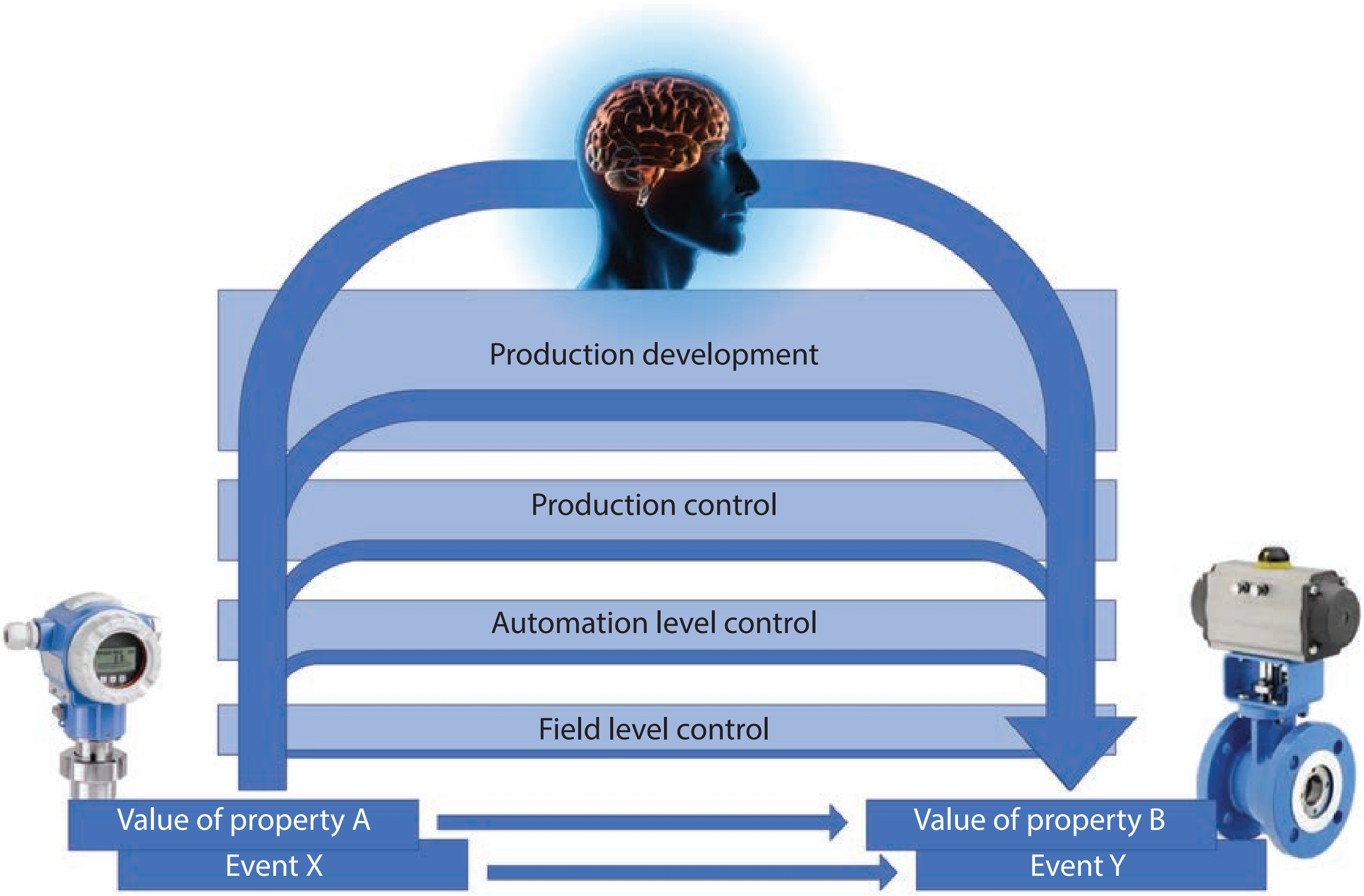
As the industrial IoT field becomes more diverse, a lot of information will become available from a variety of sources. This opens new opportunities for more refined information about production statuses, efficiency and productivity. There is a growing need to make all useful information accessible to data processing, both locally and in the cloud.

The prevailing trend has led to a situation where there are many thematic applications and system solutions on the market. Therefore, an increasing amount of aggregating and virtual platforms will be needed to structure data masses into real-world comparable models, to describe interrelationships of data structures, and to determine the dynamics of data and data relationships. The key dimensions of the system are structures, relations, and functionality.

There are 4 levels of information processing. The knowledge layer includes the collection and storing of information. Understanding includes data analytics and the intelligence level can apply understanding. The wisdom level produces creative solutions and sustainable innovations.

The actual data collection and storing of data into databases is already well advanced. The focus is now

Figure 4. Levels of production management and control on MES level.



shifting from traditional data acquisition, data processing and reporting functions to computing and visualising smarter statistics, event correlations and predictions. The purpose of the indicators is to help in quickly identifying critical situations and change dynamics that are critical to achieving the goals. They are a summary of the knowledge level.

Analysing the interdependencies between events and property (attribute) values allows a better understanding of processes. The digital model enables intelligent operations that can be performed autonomously by the systems within given limits. The top-level mission is to help the developer and the decision-maker to develop wisdom.

All intelligence itself is not wisdom. Intelligence is the ability to do the right things. Wisdom is the ability to do something well. At the highest level, the optimisation task entails developing, managing and steering production and business operations with consideration for external influencing factors.

The digital twin of a highly advanced production unit enables the system structure at all levels to include self-steering features. This means, for example, that alongside traditional production control, there is a meta-control level of production automation control that tunes the automation itself to work better with technologies such as Advanced Process Control or Multivariable Model Predictive Control.

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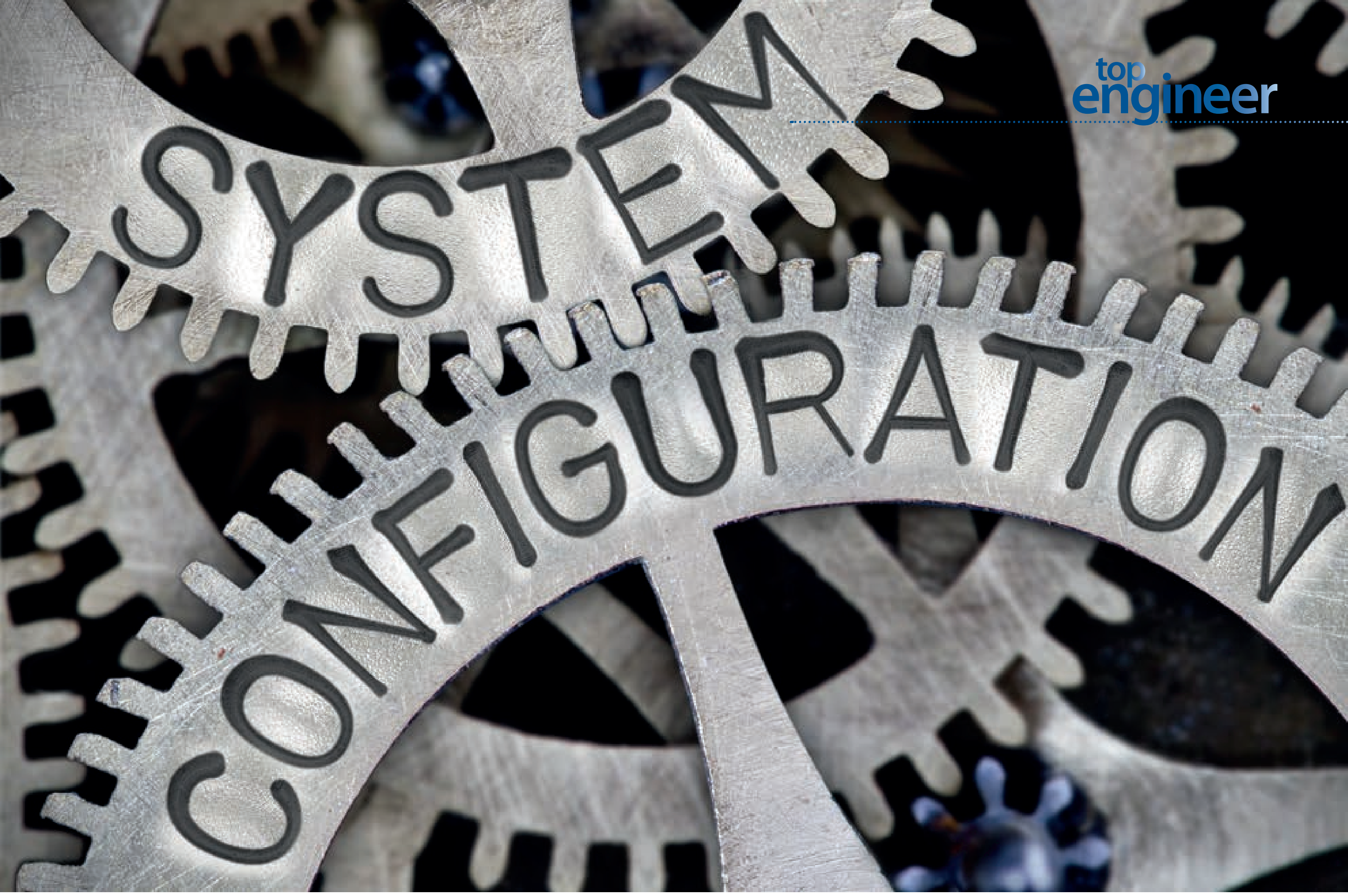


Device software explosion posing production problems

Text: Petri Mähönen / Devecto Oy

The amount of software in devices and equipment has grown significantly in the last decade. Features implemented through software enable personalisation of equipment to the customer's individual needs and the addition of features that are difficult or impossible to achieve otherwise. The increasing number of software features, however, comes with its own set of challenges for production.

Simply put, in devices that consist of both mechanical properties and software, one element always affects many others. Consider a car, for example: If a customer decides to have an electric handbrake feature, this immediately affects ten parameters that must be combined in production. There are many such features and even more related parameters.

These combinations are currently handled manually, which is slow, prone to error, and consumes human resources. This is exacerbated by the fact that the number of combinations is constantly increasing.

Creeping risk, hidden problem

When software was added to purely mechanical devices in the past, the number of software features was initially rather modest. The number of parameters that needed to be combined was also small and, therefore, it was natural to manually manage the combinations in production.

▲ *The features chosen by buyers of modern cars are largely software-implemented or assisted.*

With the explosion in the amount of software, the number of combinations that need to be manually built has grown exponentially.

Thus far, parameter management has remained under control, mainly because of configuration specialists that are able to handle all the variations. An increasing number of manufacturers are nevertheless reaching a critical point. The situation may not have gotten out of hand yet, but it is not far off.

Changing role of software in devices

Device manufacturing has changed with the increased use of software. Previously, devices and their mechanical features were the core components of products, to which software was added for differentiation. Nowadays, software is an integral part of all products and devices with complex functions.

A passenger car is a good example in this case too. In earlier times, the buyer's choices were based on the mechanical features, whereas features brought by software were somewhat of a luxury. Today, the features the buyer chooses are largely software-implemented or assisted.

The amount of software is constantly increasing. From a production point of view, this translates into a vast number of additional parameters that need to be set.

To illustrate this point, the analogy of baking gingerbread can be used. The software data mass can be seen as the dough ball from which production bakes the finished gingerbread. Because the parameters are set manually in this analogy, the gingerbread is shaped by hand without a mould. This kind of manual work is time consuming, contains errors and results in varying production quality. It also leads to production scaling difficulties if order volumes increase.

Configuration management is the solution

In order to automate the manual combination of parameters, connections between the systems in use must be established. This means implementing connections between the different systems responsible for product data management, order handling, and production.

As manual labour decreases, production processes are able to produce more consistent quality.

Currently, all software features and their related parameters are contained in the product data management system. The order handling system lists the features that the customer wants for the ordered device, while in production, everything is manually combined into the finished product.

The automation of these processes can be accomplished with configuration management, which is an important part of broader product lifecycle management. In the gingerbread analogy, the configuration management solution is the mould used to shape the gingerbread. It can be used to retrieve the desired features for the product defined in order handling. At the same time, feature-related parameters are automatically retrieved from product data management, from where they are redirected to production as work orders.

Configuration management can be implemented either by integrating it into the product data management system, or by creating a completely separate solution.

Benefits of configuration and lifecycle management

As manual labour decreases, the ability of production processes to produce consistent quality improves. At the same time, the capacity of production to respond to increasing volumes is also enhanced.

Another significant benefit is the traceability of devices. When parameters are combined manually, there is usually no clear documentation of the final device, its software, and parameters. With the help of automation, every completed device comes with an electronic "birth certificate". This documentation also contains later software updates, which means that it can be used in troubleshooting, warranty-related matters and for after-sales service.

The solution furthermore enables the generation of a digital twin, or virtual version of the device. The digital twin can be generated before actual production, which creates opportunities for versatile testing of the device before production.

Adapting to changing environment

Past production processes were justifiable due to the operating conditions of the time. A changing world means that such practices have become inadequate. This has driven the adoption of new approaches and practices.

The silver lining to this latent problem is the business opportunities it creates. In some way or another, all device manufacturers will have to take a stand on the matter. The ability to turn challenges into opportunities will separate the best manufacturers from the rest.

Elomatic and Devecto collaboration: Broader digitalisation solutions for industry

In early 2019, Elomatic and Devecto started collaborating in developing industrial digitalisation solutions. The aim of the cooperation is to further strengthen the competitiveness of Finnish industry and to ensure the success of customers in ongoing technological and business model changes.

The partners combine Elomatic's long experience in industrial design and consulting with Devecto's strong expertise in technology industry product development and software solutions.

The cooperation has created a new comprehensive partner, especially for the development of large-scale industrial solutions. The collaboration covers business and service design, intelligent automation and system solutions, embedded solutions, testing and software robotics, analytics, and knowledge management.

Data collection and analyses in the marine environment

Text: Juhani Kankare

In recent years, much noise has been made about digitalisation in the marine sector. The related development areas include, among others, autonomous navigation and steering for ships, as well as more advanced ship automation systems that ease the lives of crew and owners. In leveraging the benefits of digitalisation, data collection and analysis have become key focus areas.

Today's ship automation systems have been able to capture all possible operational environment and ship status data for several years already. This has made a massive amount of data available for fleet owners. Generally, this data is not collected for deeper analyses.

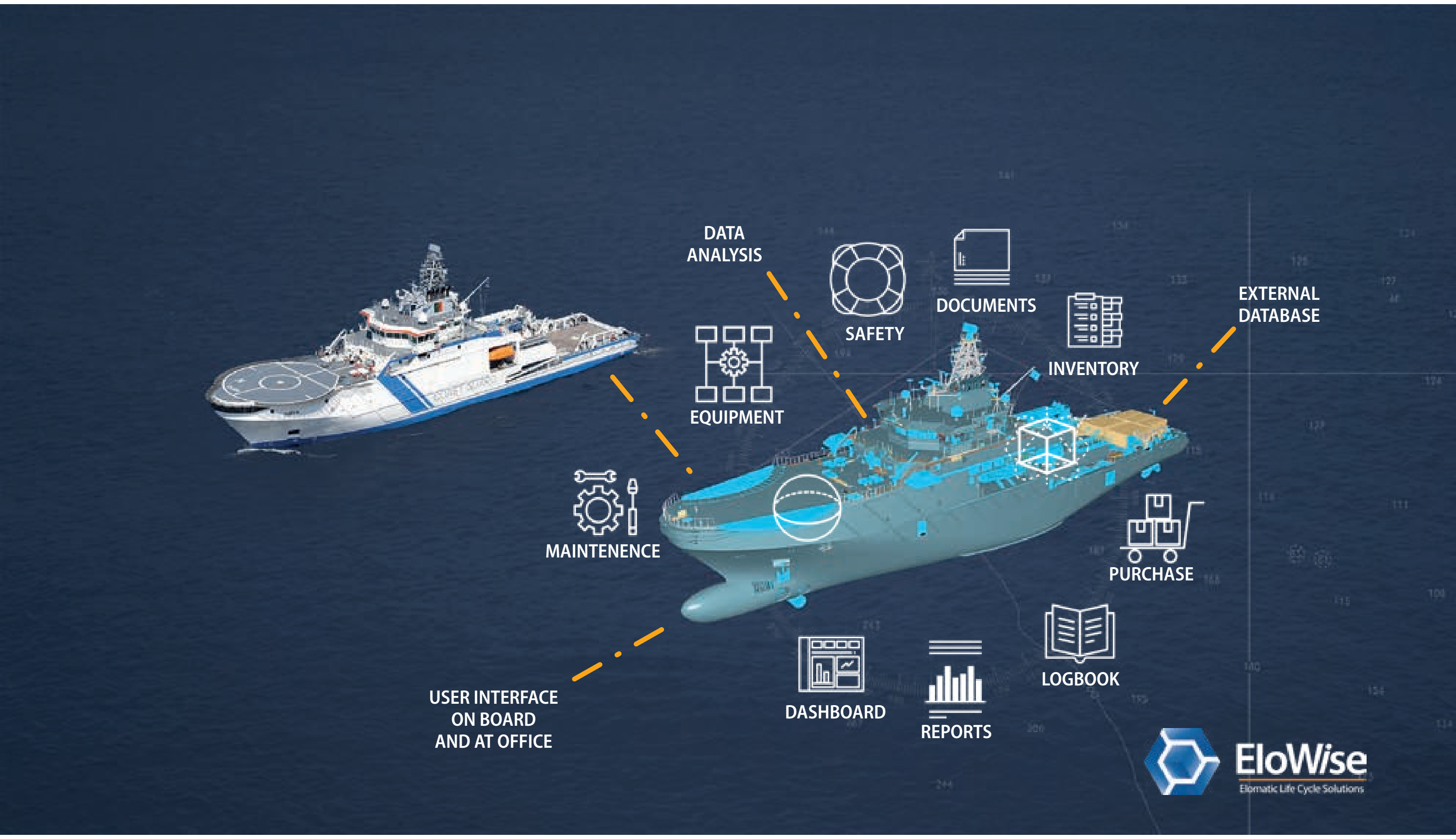
Many manufacturers also send data from devices to their own cloud storage. They are naturally not interested in sharing this data with competitors. This, in turn, leaves shipowners with the headache of monitoring relevant data and alerts from many different sources and systems.

This time 1+1 = 3

Analysing the combined data from several systems as a whole expands knowledge of the entire fleet operation and maintenance cost structures. One can improve a ship's operational awareness and react to related incidents or performance issues faster by capturing ship parameters such as location, speed, heading, wind, systems statuses.

However, by using a much greater amount of combined information for concurrent analysis (big data), far better results can be achieved than by following individual

Analysing combined data from several systems expands knowledge of the entire fleet operation.



measures of individual ship systems. It is, for example, possible to compare current and historical data to inform the crew of more optimal driving parameters. One can also estimate the need for possible upcoming services, maintenance or docking schedules.

When an online data connection between the ship and the shore is added, a live MIMIC-view can be achieved with all the statuses and video connections from the ship to the owner's remote observation centre. Operators in the remote observation centre can support the crew fleetwide when needed.

Improving operational fleet costs

Data collection systems allow the monitoring of individual indicators via a dashboard. More advanced functionalities can, however, be set up so that the analysis of large amounts of data can generate more information. This includes:

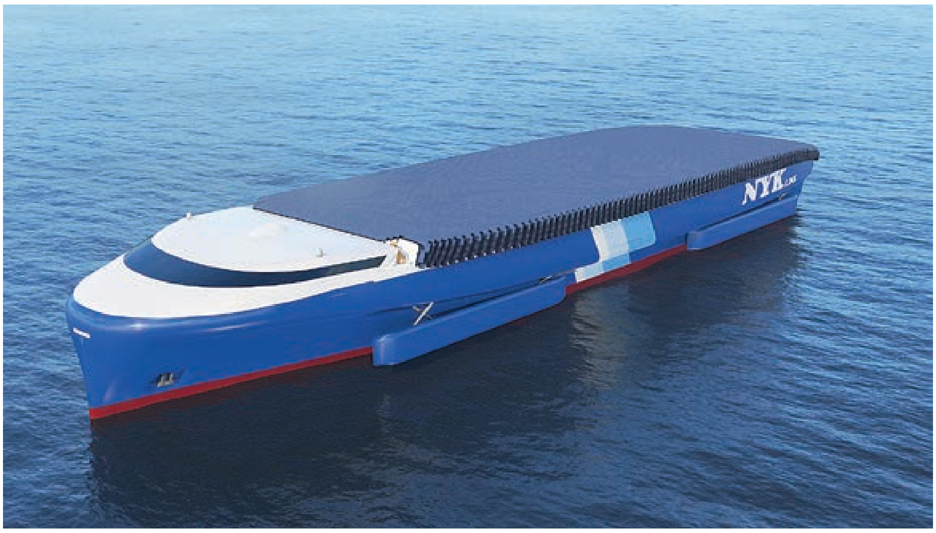
- The most effective way of running a ship in certain conditions
- Service needs
- Docking planning
- Consumption in different conditions and routes
- Benchmarking different ships (or crews) with particular routes
- Service management such as inventory and purchasing of spare parts

Autonomous ships

Autonomous ship technology is a big development area in the marine industry that has been driven by digitalisation. Several companies are investigating and investing in technologies to enable unmanned ship operation.

The ultimate goal is cargo ships that can operate fully autonomously between continents. The reality is, however, that the current technology can only

The Finnish Border Guard vessels Turva, Louhi, and Tursas run the EloWise information management system.



Digitalisation has driven the rise of autonomous ship concepts.

manage small ferries that have simple operations on short routes. Even this achievement would have been considered science fiction a few years ago.

The technology is set to develop even faster over the next 10 years and has created a new group of start-up companies, also in Finland. At the moment, several companies are researching and developing devices like sensors, as well as AI software applications for image recognition and navigation for the next generation of autonomous ship systems.

This technology will not immediately enable fully autonomous ships. Future innovations will be taken into use incrementally according to technology availability and price levels. In the first phase, a computer will alert crew members about issues it recognises in the environment. The next step will be computers that can advise the crew and guide decision-making, i.e. computers that execute actions only once the crew approves. After several small steps, the ultimate goal will be fully autonomous actions without the need of crew participation.

This final milestone will significantly affect the exterior of cargo ships as well as the interior arrangements, due to the decreasing number of crew members on board. There will be no need for accommodation areas on cargo ships as no crew members will work permanently on the ship. Much of the technology and many spaces can be removed once there are no humans on board.

Autonomous ships are observed and controlled remotely. It is essential to develop online data collection and analysis to enable advanced remote control of ships.

In addition to the real-life ship, there is need to create a digital twin to allow the ship crew and remote workers to have the relevant statuses of the ship at the same time.

EloWise data collection and management system

Elomatic has developed a first-generation data collection and management system called EloWise. The system has been used both in marine and shoreside industrial environments.

EloWise can be tailored for use in the digitalisation of fleets. It is simple to build up a digital twin with the EloWise system with the use of original ship design information such as the 3D model and other design documentation.

Later on, more information can be added such as 360° photos or even live video streams, if needed. EloWise can be used for handling ship automation data collection, service management tasks such as inventory control and purchasing of spare parts and a digital twin approach both onboard and onshore. Currently, EloWise is used onboard the Finnish Border Guard vessels Louhi, Turva and Tursas.

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XR Technologies

Bold steps to new realities

Text: Felipe Madiedo

The simulation of reality has developed vastly in the last decade, and the pace of the development is increasing. Virtual and augmented reality have become buzzwords and artificial intelligence (AI) is shaping up to change mankind for better or worse. Applications can be found in industry as well as in the gaming world. Where is simulation going and how will it shape our world?

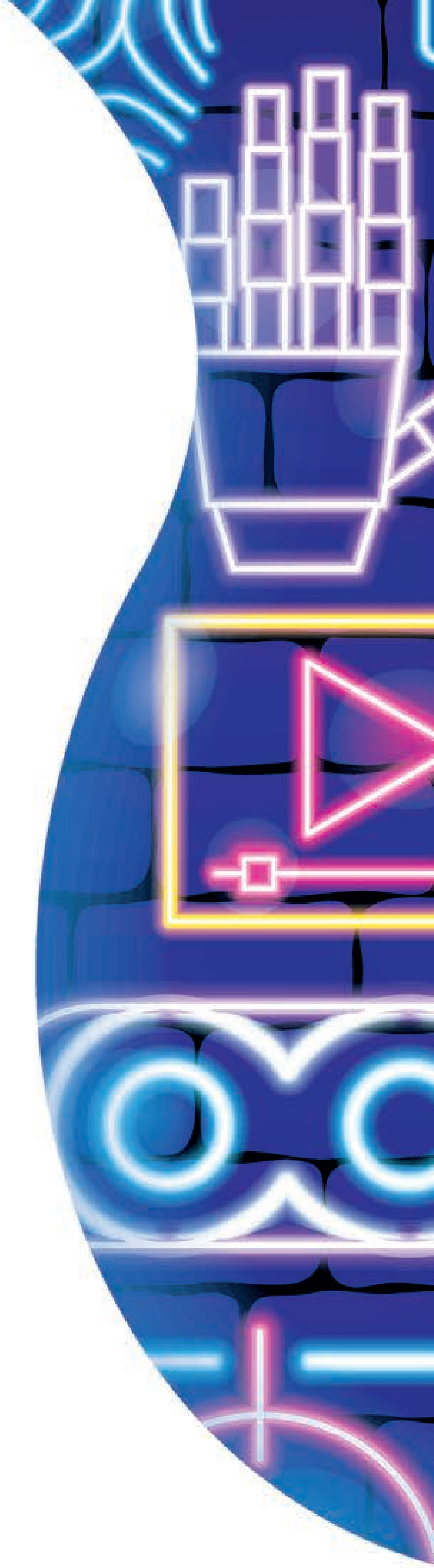
Faster, better, and simpler are words that drive industry. Instant gratification and consumption are the order of the day. The more one knows about the world, the more one becomes aware of experiences that are missing. But what is an experience? What makes a trip more real than a simulation of the same trip? What is missing?

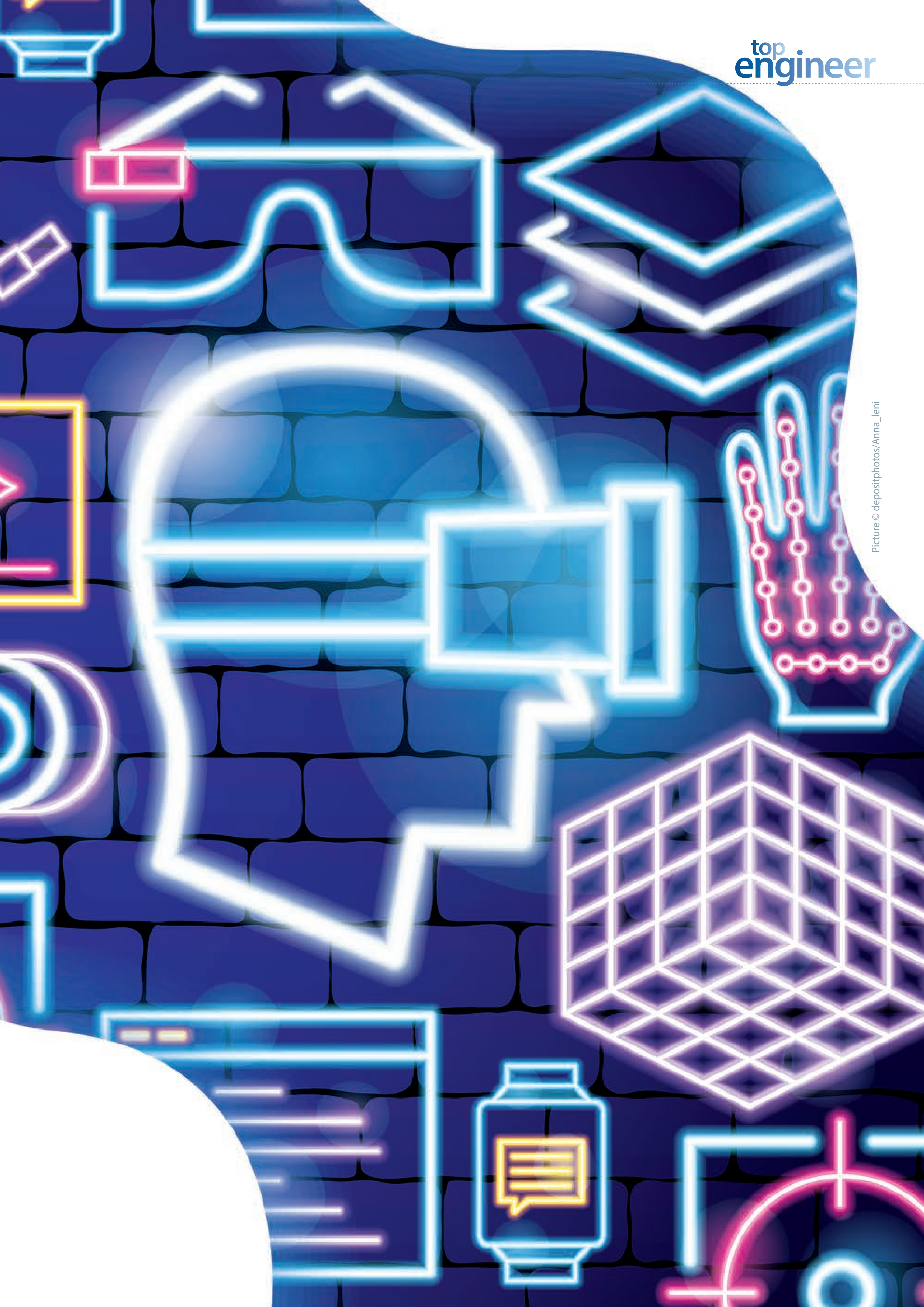
The birth of different realities

X Reality (cross reality / XR) encompasses multiple forms of artificial realities such as augmented reality, virtual reality and mixed reality.

Augmented reality, as the name implies, seeks to add artificial entities such as data, text, and objects to a physical environment. The entities are visible through a camera that recognises physical trackers and places the entities according to the location of these trackers.

Virtual reality is an artificial environment created with the intention to simulate self-presence in an environment with the use of a head-mounted display (HMD) that tracks head movements and position thanks to cameras or lighthouse boxes.





Picture © pixabay: FunkyFocus

Mixed reality is a combination of both technologies. In mixed reality users experience a virtual environment, yet some of its components are anchored to real-life physical objects.

A collective interest

Communication is incredibly important for all living beings; visual inputs, sounds, smells, tastes and sensations are ways of gathering information from the environment, thereby increasing human chances of adapting and surviving. There is, naturally, no longer the need to survive in the wild. Humans are, nevertheless, highly dependent on information. It is not always important how the information is obtained, but rather how easily it is understood.

Information has become much more readily available to everyone – from gossip to messengers, newspapers, news channels, and the Internet. Basic knowledge is no longer a luxury and even academic diplomas are no longer an advantage in many fields in the same way that experience is.

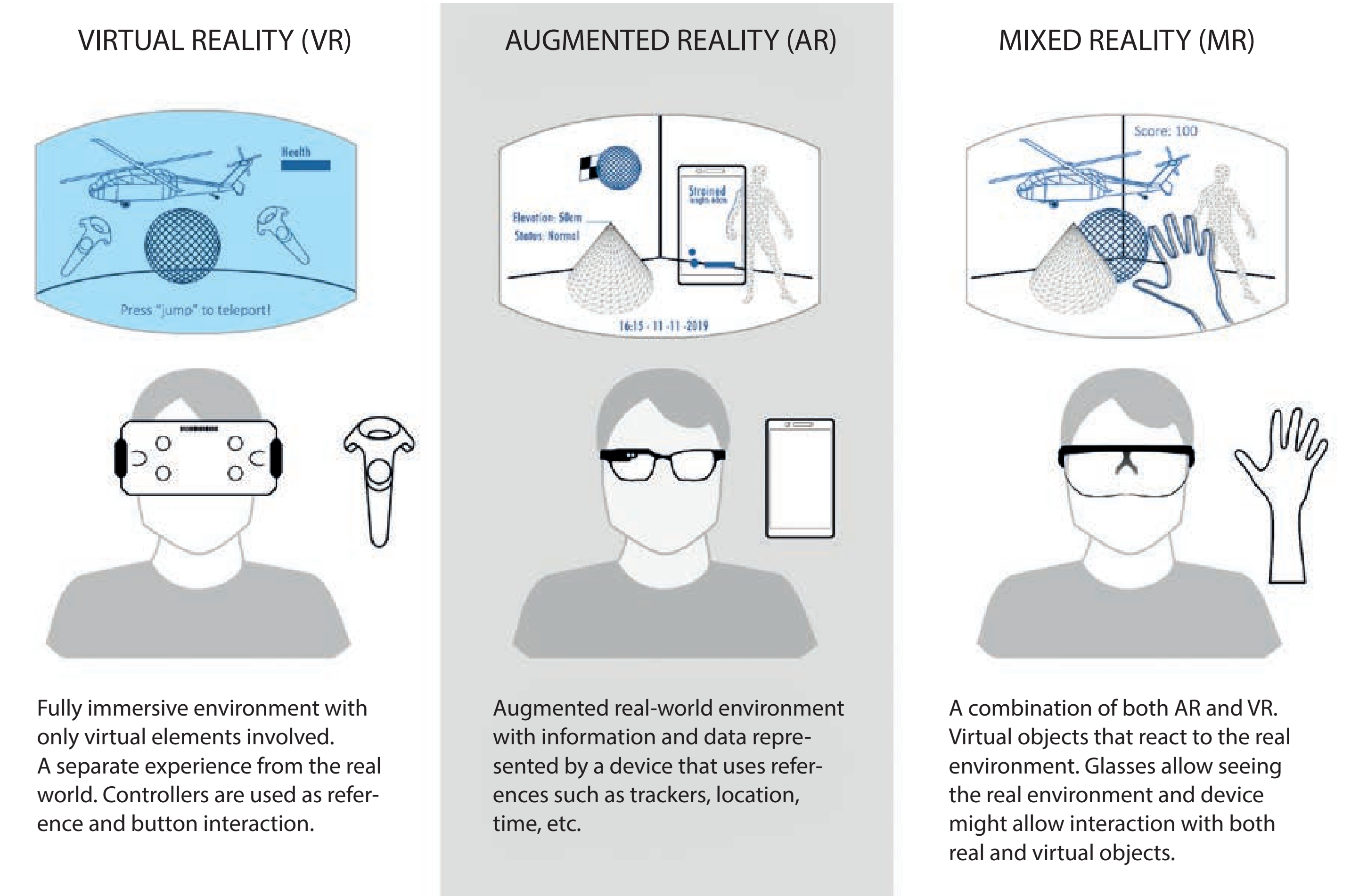
Simulators have long been used as tools to gauge performance. The line between simulation and reality is shrinking quickly as new tools and software are developed. If simulations are combined with AI, completely different scenarios to test users can be developed. This allows learning in a more involved manner than with a textbook.

Room for both the old and the new

It always takes some time for new technologies to be adopted. The number of detractors usually peaks when the technology is new and untested; many fear the consequences and are blinded from the benefits. History has shown, however, that it is always a matter of time: vehicles did not make human legs redundant, emails are extremely convenient, but people can still write letters if they wish. Cell phones replaced many technologies, but specialised tools are still sold.

Standards are difficult to predict, before the Internet was invented, it was difficult to imagine it. VR and AI together will not replace the cinema or drivers and it will take time to reach conclusive opinions about it. Perhaps it is the fear of no longer needing human imagination or of losing more control to technology that makes some people reluctant to adapt.

Some doubt the viability of VR movies, claiming that it is impossible to keep an audience focused with such



▲ *An illustration of the similarities and differences between VR, AR, and MR.*

freedom. The theory is that they will likely miss important details of the story if they are easily distracted. However, these kinds of movies are possibly not meant to be seen once, or in a room with many people.

More than a game

There is still a stigma attached to games and the people who enjoy them. The biggest concerns are the inability to separate fiction and reality and the normalisation or celebration of actions that are not deemed acceptable in society.

The debate will probably rage for several more years, but attitudes are changing gradually. Games are not only the means to live a fantasy, but a means to engage with others, to test skills or develop them.

A game is a structured form of play: rules and boundaries are set, and an objective is explained. A well-crafted videogame easily relays these rules and objectives to the user: how high one can jump, what can be interacted with, what rules end the game, and what is the objective.

Similarly, a well-crafted application that monitors health not only keeps track of numbers but can also challenge the user to reach an objective. It can provide an environment with rules to follow as well as visually appealing functionalities to help the user focus on the objective.

When considering realities, it is important to talk about immersion. After all, if one wants to build a machine, many factors such as the scale, parts, and procedure are important, but moving a machine is not always a cheap option, neither is having it maintained on site.

Nowadays, a virtual copy or digital twin of a machine can be created with the use of surrounding data to predict behaviours, or at the very least to gain a realistic and updated status of the machine.

A digital twin can bring many benefits to many industries; it is not always necessary to add artificial components to a machine as the data obtained is

Taking a trip to an exotic island with fantastical creatures may be as simple as ticking a few parameters.

valuable itself. However, there is a branch that takes digital twins further: artificial Intelligence (AI), or more precisely neural networking, which can assist in troubleshooting machine behaviour by understanding patterns and suggesting solutions.

Patterns everywhere

The term artificial intelligence was coined back in 1950, but the idea of artificial beings developing intelligence has been around for centuries. But even with the immeasurable advantage machines have over humans, in some fields the biggest disadvantage they have is the lack of pattern recognition.

Neural networking algorithms seek to emulate human brain-pattern recognition based on the comparison of data. How does a human recognise 1 as 1? What about if it was written as I? Effective algorithms do not provide a single answer to the above-mentioned questions, but a set of answers with a conclusion.

Everyone is an architect

Game engines have come a long way. Not only are there multiple options to create applications, but there is a vast number of sources to learn and improve the game skillset as well as tools to ease development.

Anyone can engage in creating their own environments or team up to tackle larger projects. It takes a few hours to grasp the basics, and minutes to publish even an empty space with a cube on multiple platforms, from a cell phone to a PC as standalone or virtual reality enabled.

The biggest players right now are Unity3D and Unreal Engine. They are constantly pushing their respective engines to appeal to different kinds of developers, including VR-focused ones.

As technology keeps evolving, it may no longer require hours to generate content. Taking a trip to an exotic island with fantastical creatures may be as simple as ticking a few parameters. In such a world, education will be both academic and empirical without costs and risks. In short, it will be a world where simulations can provide all the answers.

Universal simulation

Will perfect simulation be possible in the future? It is currently possible to simulate images, sounds, smells, and tastes. Haptic feedback is slowly advancing, but why would one want to feel pain from a virtual source?

All available senses are important to humans and the joint perception makes experiences "real". The fear of pain from haptic technology is understandable, but not much different to the fear of hearing a deafening or screeching sound or that of food that is met with immediate rejection. It is natural to try to avoid these sensations, but musicians and chefs need to be exposed to both good and bad music and food.

AI that learns from human feedback can provide unexpected, yet enjoyable or challenging scenarios that allows all senses to take part in experiences.

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Felipe Madiedo started working at Elomatic in 2011, a few years after graduating from the Nueva Granada Military University in Bogotá, Colombia. With almost 10 years' experience in various multimedia fields, he has developed skillsets in both technical and creative content creation. Felipe currently works as an Application Developer in the Visualization Team at the Elomatic Jyväskylä office.

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Data analytics and AI technologies

Tools for technical consultancy

Text: Jussi Jääskeläinen and Jussi Parvianen

Running an industrial manufacturing operation is a massive undertaking consisting of complicated and intertwined processes. Managing each area well is crucial in running a successful business. One of these processes is data collection and management, which is boosted by the application of artificial intelligence.

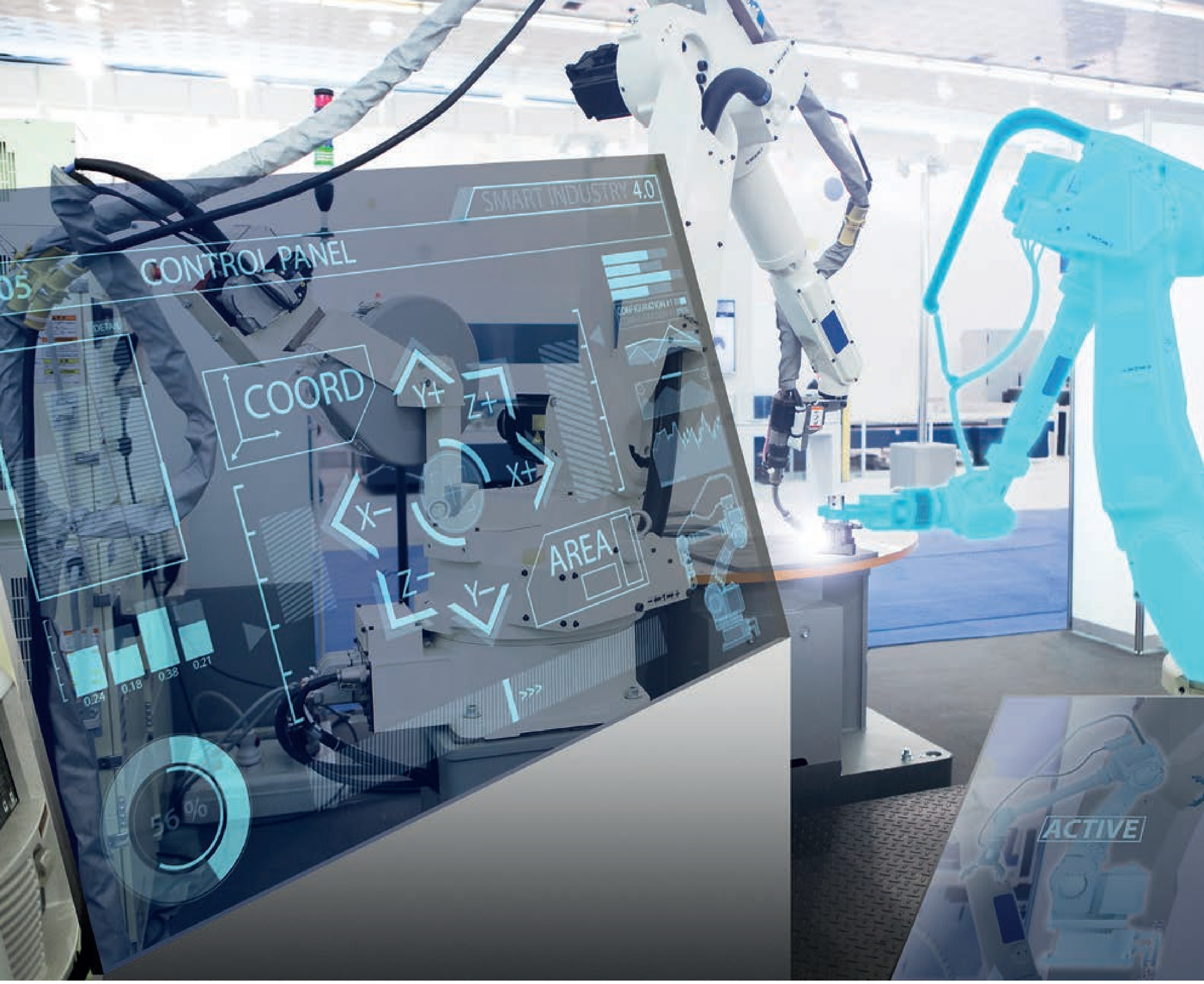
Process automation systems produce heaps of measurement data, and the means of tackling this flood of information is through data analysis. Modern data analysis tools make it fast and efficient to search for deviations and bottlenecks in processes. With the addition of artificial intelligence technology to process data utilisation, more efficient process control parameters can be found

Process knowhow is still needed

Besides modern tools and comprehensive measurement data, another requirement for meaningful data analysis is expertise. This is where an engineer's know-how comes in. In order to find, for example, ways to make production lines use energy more efficiently, an understanding of the inner workings of the underlying processes is needed. Therefore, it is usually bestowed upon an engineer to find the right control parameters and technical solutions to improve process efficiency.

Data utilisation can also be harnessed at the process operator level. This is achieved in the form of, for example, efficiency indices and the visualisation of process parameters which makes it easier to interpret the state of the process. The choice of which parameters and indices are monitored is also crucial and affects the way processes are operated.

The causality between adjusting process parameters and changes in efficiency/quality can be discovered with explanatory data analytics. Identifying these relationships helps in running a process close to its optimum in terms of efficiency, quality and costs. Usually, these dependencies can be found with traditional data analysis, but when no clear relationships are found or when



the dependencies are multi-dimensional, the use of artificial intelligence can be considered.

Artificial intelligence – next step for process optimisation

Artificial intelligence can take data utilisation and its benefits to the next level. The use of AI to predict certain product quality features, for example, can generate remarkable efficiency and productivity improvements. The point is that product quality is quite often measured after it has been produced and possible deviation can be detected afterwards. If quality deviation occurs, production losses are incurred. This may be tackled by using AI to model the effect of the process parameters on the quality features. In the best-case scenario, the tools to avoid quality variations are in our hands.

Another area where artificial intelligence can be utilised is improving energy efficiency. For example, heat energy utilisation mostly depends on weather conditions. By analysing data from heat production and heat use and combining this with weather information, energy use can be predicted and preparations for forthcoming heat peaks can be processed accordingly. This may, for example, entail increasing the network temperature in advance or the heat content of separate thermal energy storage. On the other hand, consumption can be adjusted in consumption networks to optimise total consumption. This may avoid the use of fossil fuels in reserve boilers. A similar process can be utilised in the optimisation of electricity use in an electricity network, even though the means of optimisation may differ.

Digital twin for process/ equipment development

Process efficiency and product quality can also be improved by investing in new equipment. In order to find suitable technical solutions, deeper knowledge of each solution's applicability is indispensable. Through data analysis,

Picture © depositphotos.com/Scharfsinn

Artificial intelligence can take data utilisation and its benefits to the next level.

the viability of each solution can be assessed reliably and in detail. This provides engineers with more important data to design solutions that are more productive. Once enough data is available to create a digital model / digital twin of a process or equipment, process optimisation, development work and test runs can be done digitally. This minimises the risks of development work.

Digital transformation taking place

The industrial sector is somehow facing digital transformation in every function, starting from raw material supply and logistics, customer management, financial management and production planning, up to execution and control.

This may cause confusion and difficulties in selecting new digital solutions that are the most suitable. Reliable co-operation between service providers and users are vital here. New solutions must provide clear benefits for users and introduce new solutions. Training users is also very important in implementing new methods.

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CONSULTING & ENGINEERING

Scientia vires est

At Elomatic we believe that our human capital is our most precious asset. With knowledge comes the power to shape the future.

We continuously develop our employees' know-how and strive to be leaders in our respective technical fields. We focus on packaging and delivering this know-how to ensure that our customers stay ahead of their competition.

The Top Engineer magazine offers our experts the opportunity to share their expertise and knowledge and to engage other technical experts with their writing. It is a publication by engineers, for engineers, and other technically-minded readers.

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Elomatic fighting climate change

Elomatic has donated its funds earmarked for 2019 Christmas gifts to the WWF's Christmas campaign to fight climate change.

By the end of July 2019, the world had exhausted its calculated renewable natural resources. By giving staff or customers an intangible corporate gift, we can reduce overconsumption, one of the biggest causes of climate change and environmental degradation.

Elomatic is committed to designing solutions that increase the well-being of the environment and people. We support our customers in their struggle against the most significant challenges of our time. The greatest of these are environmental well-being, resource sufficiency and questions related to technology upheaval.

Elisabeth Kruger / WWF-US