DIMECC Program
D4VALUE

DIMECC PUBLICATIONS
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D4V – Design for Value Program Report

2017–
2018

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PREFACE

The era of digital transformation of industries is ongoing. It has been major topic of discussions and debate for years already. The flow of new topics and themes is continuous: internet of things, industry 4.0, big data, machine learning, blockchain, artificial intelligence etc., etc. It is commonly stated that speed of change is faster than ever, even though there are no clear facts if it is actually true or not.

However, one item is clearer: It is obvious that mastering new technologies (developing the technology itself or applying the cutting edge technologies) is not enough. The technology solutions have to be brought to the customers in a novel and sustainable manner. This demands co-operation between specialists in different fields: Business studies on value creation and the ways to implement those; defining new regulatory requirements; understanding how to create safe and desired new ecosystems both from organizations' and employee's point of view.

DIMECC's Design for Value (D4V) is exactly such kind of interdisciplinary co-creation program. We at DIMECC are very happy to facilitate that work and to provide our services and expertise to get different stakeholders and excellent researchers together to solve challenging industry and academic problems.

The focus of DIMECC D4V program has been on door-to-door supply chain which is under digital disruptions and is rapidly changing towards an ecosystem of fully autonomous system-of-systems. The program has worked on autonomous maritime and manufacturing logistics use cases. Digitalization of maritime industries through autonomous shipping and services for that has provided great public attention through the One Sea ecosystem work. Rolls-Royce, who is leading industry partner of DIMECC D4V program, has provided innovative insights on the next stage of shipping to the whole industry globally. DIMECC D4V program has important role also in autonomous maritime One Sea ecosystem roadmap implementation.

The research work has been facilitated through joint pilots and concepts. We have called those concept themes as integrated data flow, local & remote operation excellence, and fully autonomous operations.

The work has been conducted under three major themes:

- Value creation and business models in ecosystems: What are the business models and ecosystems to enable business growth during and after digital disruption
- Technology and solutions: What are the key technology solutions to enable, drive or restrict digital disruption
- Desirable ecosystem: How to engage companies and their employees in the new ecosystem, and external stakeholders in the change?

The program was prepared during 2016 and actual work was started in spring 2017. In addition to the articles gathered into the report, the partners have actively participated in common reviews, workshops and pilots with many other outcomes not described in present document. During the program, the collaboration has been conducted globally with businesses and universities in Singapore, Norway, UK, Germany, US, Netherlands, Estonia, Sweden, Switzerland, France and Australia.

The work in DIMECC D4V program has been a starting point and will certainly continue in a new program under preparation within One Sea. Solutions for autonomous logistics are far from ready. DIMECC has enjoyed working with the consortia and is happy to further enhance such co-creative work.

Such public programs cannot be possible without funding support from Business Finland. Program consortia is thankful for Business Finland and especially to **Rauli Hulkkonen** as contact person from Business Finland for smooth collaboration. Here you have at hands snapshots of the results achieved during 18 months. Enjoy the reading.

Ülo Parts
Program manager
DIMECC D4V program

Creating value through digitalisation

The high-level vision was to increase autonomy in the whole supply chain. For this purpose, a carefully selected consortium was gathered including industry partners and research organizations. The program aimed to enable the best possible use of digital disruption for business growth.

The basis for the program was a strong industry demand. This was emphasised by the rapid development in different supply chain parts – including factories, ports and ships. The program focus was put on door-to-door supply chain, where digital disruption is taking place. A special scrutiny was based on business ecosystems and customer value as these enable effective way to challenge the existing business models and roles of the actors in the current value chain. Although, changes are ongoing in many fronts of the supply chain, the overall value network has not been disrupted yet. Therefore, there are significant uncapitalised value potential for the companies, if an ecosystem approach with keen business value focus is applied in this area.

Logistics is a key part of the door-to-door supply chain and contains several complex phases in which the digital disruption is still to come. Based on the original program plan, all organizations were able to make R&D work with one another as long as it was within the project scope. Especially in the autonomous shipping, DIMECC D4V program had a critical role as it is the first ecosystem level approach in the area. Although the autonomy was raised into the focus, DIMECC D4V addressed also other critical supply chain parts and their digital value creation questions. Due to wide the range of organizations and their background, the conducted work was diverse but at the same supporting one another. On a global scale, a recent industry analysis of the cargo flow and logistics chain had revealed significant inefficiencies that could be turned into new business opportunities.

Some of the key questions in the DIMECC D4V program were to explore critical ecosystem partners and their dependencies. Also their motivations and demands for the change were questioned. At the same time building a flourishing start-up and SME partner network in the area of autonomous supply chain was explored. Autonomous solutions are a radical digital disruption for the ports and shipping, where the autonomous system markets are clearly a blue ocean market. Automated systems operate more efficiently and consistently than humans. Over time we start to see less and less people needing to supervise some of the systems, functions and processes.

The main goals in DIMECC D4V program were to lower costs and increase value to end customers operations. At the same time higher level of safety and security were important factors to achieve. The gained results in DIMECC D4V program included many benefits for the customers in ecosystem. The project consortium included 6 large companies, 5 SME's and 9 research organizations. Besides collaborating with these partners, the project included a lot of subcontracting and startup cooperation.

Anssi Lappalainen
R&D Project Manager
Rolls-Royce

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SETTING THE COURSE TOWARDS AN AUTONOMOUS SHIP

Rolls-Royce is studying how the amount of crew on the bridge could be decreased. It is a step towards an autonomous ship. Sea trials on an autonomous and remotely controlled vessel were performed in the Turku archipelago in late 2018. This was the first demonstration in the world with a commercial autonomous vessel.

The advantages of an unmanned ship are irrefutable. Without a crew, there is no need for living quarters, a food supply, air conditioning, heating or sewage systems. Unmanned ships can be designed to be lighter and more aerodynamic, which reduces fuel and energy costs. They can fit more cargo. There will also be fewer accidents, because the majority of maritime accidents are caused by human error.

"The technology is now ready for removing men from the bridge every now and then"

In the DIMECC D4V program, Rolls-Royce, the University of Turku and Aalto University studied regulations related to international seafaring and their revision. Regulations need to be revised when unmanned ships are being designed. Fully or periodically unmanned bridges are the first steps towards an unmanned ship whose operations are handled by remote operating centres situated on the coast.

"The software and technology exist, but the other areas still require work," says Rolls-Royce R&D Project Manager **Anssi Lappalainen**.

At the moment, the authorities of different countries determine minimum crew size based on the type and size of the ship. In Finland, a Minimum Safe Manning Document is obtained from Trafi, the Finnish Transport Safety Agency.

"The technology is now ready for removing men from the bridge every now and then. A human will still monitor the decisions made by a machine in a remote operations centre."

Future Operations Centre.

The operation of the ship is steered and monitored by several sensors that produce data which provides operators in the remote operations centre an adequate situational picture. Rolls-Royce has built three remote operations centres (Rolls-Royce Remote Operations Centre, ROC). There is one centre in Copenhagen and two in Turku, one of which is used by Rolls-Royce's customer.

In Copenhagen, Rolls-Royce demonstrated a remote-controlled tugboat in February 2017. With the permission of Danish maritime authorities and the insurance company, the 28-metre tugboat named Svitzer Hermod moved in the Copenhagen harbour under remote control. It was the first remote control of a commercial ship in the world. The tugboat left the harbour, did a 360-degree turn and returned to shore. The movements of the tugboat were controlled by its captain in a remote operations centre. During the 16-hour test, cyber security was also tested, and mandatory security requirements were passed.

During 2018, Rolls-Royce also did experiments in Finland regarding the technology of autonomous and remote-controlled ships. Manning on the bridge has been reduced and ships close to the shore have been controlled remotely. In December, the first commercial autonomous vessel was demonstrated for the first time in the world. Finferries' road ferry Falco travelled the two-kilometre distance from Parainen to Nauvo autonomously and under remote control.

Unmanned ships are initially intended to operate close to ports and in coastal waters due to goodconnectivity. For now, a crew is still needed in the engine room.

Laws and regulations must be considered, so it has made sense to operate within the waters of a single flag state.

"When a ship moves far from the coast, data transmission into the remote operations centre becomes a challenge. The volume of data from five HD cameras, for instance, is huge – 25 megabytes per second," says Anssi Lappalainen.

Reducing the manning on the bridge requires advanced technology. Rolls-Royce has developed an Intelligent Awareness (IA) product. IA provides a holistic picture of a ship's environment using advanced sensor and data fusion. IA is a factor that improves safety. The idea is that IA constantly provides data on the bridge and to the remote operations centre. The data is utilised in remote control. With Rolls-Royce's autonomous navigation system, the ship is able to navigate autonomously and make independent decisions.

The ship's operation is secured through good connectivity and cyber security. In the DIMECC D4V program , Rolls-Royce has tested the Rapid Detection Service software by the cybersecurity company F-Secure.

A new code for requirements definition

Rolls-Royce together with the University of Turku and Aalto University has studied what kinds of changes the International Maritime Organization (IMO) needs to make to allow manning to be reduced on the bridge.

Safety regulations have been considered in the design of autonomous ships.

"The background here is the Polar Code that was enacted a couple of years ago that defines certain requirements for ships operating in the arctic region. A similar code has now been developed for autonomous ships," says Lappalainen.

The Polar Code sets definitions for the design, construction and equipment as well as safety and training for ships operating in the polar regions. Now the intention is to create a new code for unmanned ships. It is called Unmanned Ship Code (USC). USC will complement existing guidelines.

Rolls-Royce Remote Operations Centre in Turku.

The aim of the code is to enable the operations of an unmanned ship and to ensure that the operations are as safe or even safer than on a regular ship. USC relies on new industry standards, such as integrated sensor systems that enable remote control.

INTELLIGENT PORT

A D4V program studied the operating principles of a smart port. Information on IT requirements and data needs for saving data and sharing it between companies was collected from different port operators. The smart port will be tested at a real port in 2019.

There is a large number of companies operating at an ordinary port. The port owns the land, the shipping companies own the ships and the cargo is handled by operators. There are also plenty of other logistics providers operating at the port. New technology is available, but how does it benefit everyone at the port? How should a smart port be constructed and what information do different operators need?

Ships' arrival at the port was a particular point of interest. The D4V program studied how the sharing of information between different stakeholders would work with the help of the situational awareness system developed by Rolls-Royce.

Rolls-Royce released it´s system in the spring of 2018. It utilises sensors and intelligent software that are a prerequisite for an autonomous ship. The safety and efficiency of ships that are currently sailing can also be improved with the situational awareness system. It can significantly improve a ship's navigation safety and produce a large amount of data on the ship's environment. It relies on an INS navigation system, day and night vision cameras, a radar, LIDAR detection (Light Detection and Ranging) and AIS (Automatic Identification System). LIDAR is an optical detector that measures distances using visible, near infrared and ultraviolet light. The system draws a 3D map and creates a detailed bird's-eye view of the surrounding area.

Rolls-Royce's Intelligent Awareness (IA) system is the only one of its kind on the market. Even though IA was developed to help control autonomous ships, it was discovered that the technology should be taken into use even before autonomous ships are ready to start operating. It can provide benefits to existing port environments.

"Shipping has been very conventional. Now, new technology is coming and changing the operating environment. Machine vision, sensors and cloud-based services are entering ports. A successful intelligent harbour can be achieved with the help of the IA system," says **Anssi Lappalainen**, R&D Project Manager of Rolls-Royce's unit in Turku.

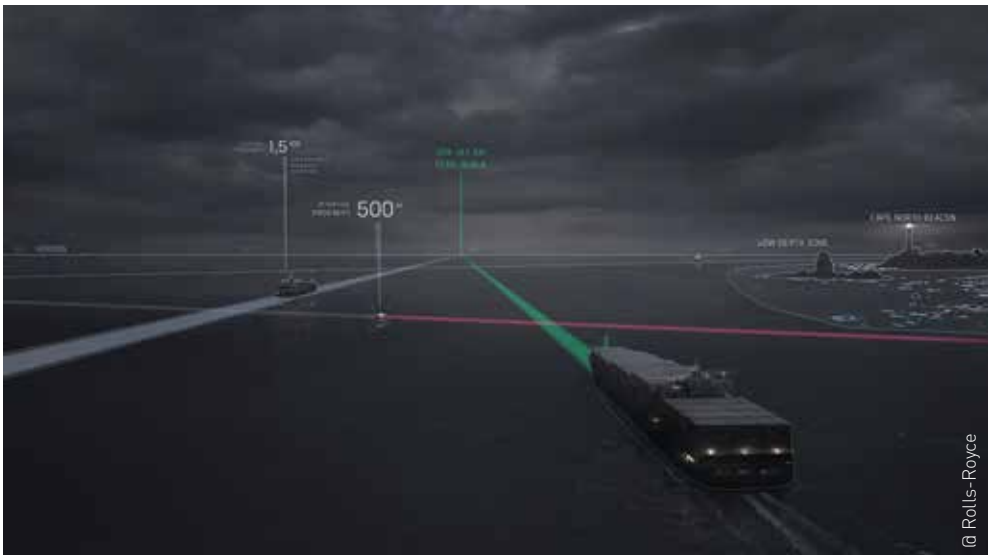
They worked together with Tampere University of Technology to develop smart port sensor technology and cameras that enable machine vision and machine learning.

During the DIMECC D4V program, other research institutes have surveyed which companies operating at the port could create an ecosystem that would utilise the same infrastructure and allow the sharing of information.

"Companies operating at the port do not share enough data with each other and there is demand for a new intelligent platform. Important questions include: who produces the data, how is the data shared, what data will be available and who can access the data."

In the D4V program, researchers have compared the operations and logistics of ports in Singapore, Estonia, Italy, the UK and Finland. The goal is to use the collected data to carry out a smart port demo in Finland in 2019.

Sensors will be installed along the shipping route leading to the port. AIS transceivers, that operate at marine traffic frequencies and enable wireless navigation status transfer between ships and the port, will be acquired for the setup. LIDAR detectors, cameras and industrial computers will also be put into use at the port. Data produced by the equipment will be transmitted to a cloud computing service.



Intelligent port utilises sensors and intelligent software Sensors will be installed along the shipping route leading to the port.

Solutions related to the smart port may generate new business.

"One such business could be remotepilotage. The pilot could work on the shore and advice the ship from a remote control centre. Sensors installed onto the ship and the fairway provide a situational picture of the environment that is good enough for the pilot not to have to get onboard the ship."

Technical management of data is a key issue in the operations of a smart port that has objects and artificial intelligence connected via data networks. The sensors are expensive and data connections must be very good to transmit data over long distances. Advanced techniques are also required for processing the data. One solution could be the edge computing principle, which takes data processing as close to the terminal device and the operating situation as possible. This would allow the utilisation of new sensor technology and efficient computing power inside the equipment.

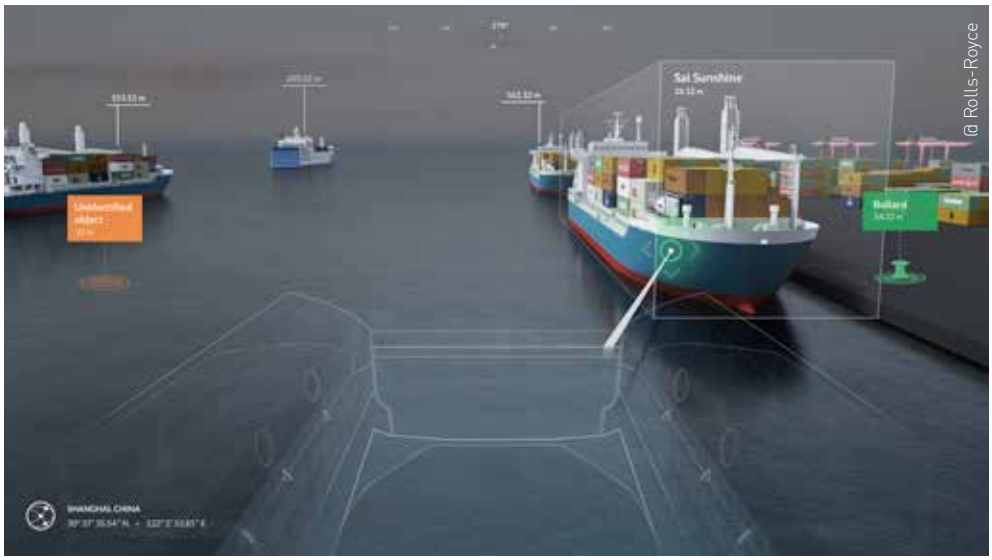
"The Finns are pioneers in developing intelligent sea traffic."

With the help of base stations, cloud-based computing resource services can be used directly on the equipment that produces the data. Smart equipment can make decisions without communicating with a server and data does not have to be transmitted back and forth.

"The Finns are pioneers in developing intelligent sea traffic. We have an opportunity to be the best in the world at this," Anssi Lappalainen applauds.

University of Turku, Aalto University, VTT, Lappeenranta University of Technology and Tampere University of Technology took part in the study on the sharing of information at a smart port.

Intelligent Awareness.



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INSURING AN AUTONOMOUS SHIP

The insurance business is in for a major upheaval as autonomous ships appear on the horizon.

Autonomous ships are theoretically ready to sail out to sea, but before commercial operations can begin, the maritime industry needs legislation concerning autonomous ships. The upheaval is not only limited to seafaring; it extends to a large area. The regulation and insurance environment inevitably needs to change with the new ships. This is why the University of Turku together with Rolls-Royce studied different insurance models for ships in the DIMECC D4V program. They studied the effects of autonomous ships on liability regulations and risk management. One of the key questions is to what extent ship manufacturers are responsible for damages caused by autonomous ships.

"Currently, liability for damages is based mainly on human carelessness or negligence. Autonomous ships challenge the conceptual basis of liability rules," says **Mika Viljanen**, associate professor of civil law from the University of Turku.

According to Viljanen, the effects of new technologies on liability issues and civil law have not been studied much yet. So far, there has been little jurisprudential research concerning autonomous cars, and similar Finnish research concerning autonomous ships has been unique.

"These are interesting issues for civil law, where the defendant has been a human. Now the defendant could be a robot. Current maritime law has not predicted the arrival of remotely controlled and autonomous ships. This creates ambiguity. For example, should the captain be on board the ship, or is it enough if he or she steers the ship remotely?"

Viljanen says we need to study how far other liability regulations reach. These include things like liability for a product and how it affects traditional maritime

regulations and insurance terms. The autonomous nature of ships inevitably introduces an unpredictability factor into insurance compensation assessment.

"We don't know for certain who is liable when an autonomous device causes damage. A machine does not make choices the same way humans do. In any case, the assessment of compensation can't be built on the old principles. What will become of it is still unclear," says Viljanen.

According to Viljanen, the concept of insurance itself may be endangered by autonomous ships.

"What do we do when we insure machines instead of people? Instead of and in addition to the unpredictability of nature, we get the characteristics of technological development processes. Are these the kinds of processes that can be insured effectively?"

We must also understand that the risks are not only related to the operation of an autonomous ship, but also to software products. If the insurer accepts the risk of an autonomous ship, according to Viljanen it also accepts the risk related to the success of a software product development process.

"The insurance business has to reinvent itself."

"The key question is, are product development processes something that, from an insurance company's point of view, can be insured in the first place? Are insurance companies able to develop methods for effectively insuring these processes? If something goes wrong with the operation of a machine, the decision-making location and the decision-maker will be different from what they used to be. It means that the accident was caused by a technical system, not by direct human carelessness, misjudgement or negligence."

Viljanen believes that insurance companies need to rethink the risks related to autonomous ships and come up with new innovative ways of drafting insurances.

"The insurance business has to reinvent itself," he predicts.

Large amounts of data are accumulated on autonomous ships. Ships have sensors everywhere, and the data flows from them are stored. In the DIMECC D4V program, Åbo Akademi researchers studied the possibilities of reducing insurance fees based on data. In their studies, they surveyed what types of data can be utilised, where the data sources currently are and how they could be utilised.

"70% of maritime accidents are caused by human error," Viljanen notes.

"Errors can be minimised if we have access to more data from the ship's sensors, for example."

AUTOMATED CRANES WILL CHANGE THE FUTURE OF BULK UNLOADING OPERATIONS

Autonomous discharging cranes, equipped with self-learning capabilities, will enable the safe, smart and efficient unloading of dry bulk cargoes from a ship, saving time and money.

MacGregor, marine cargo handling specialists, and ESL Shipping Ltd, leading carrier of dry bulk cargoes in the Baltic region, have developed an autonomous discharging crane. The first cranes will be installed on ESL's two new liquefied natural gas (LNG)-powered bulk carriers, Viikki and Haaga, which will operate on a year-round schedule, regardless of weather and ice conditions.

"On the outside, the crane looks like all other cranes, but on the inside it is unique," says **Janne Suominen**, MacGregor Cargo Handling Development Manager. "It includes new technology and software specifically designed for unloading cargo autonomously; cargo loading is achieved using conveyor belts."

The unloading operation takes place in a controlled area, which is safe and has restricted personnel access.

"Firstly, we define whether the cargo is unloaded into a pile or shore-side hopper for onward conveying or truck loading," continues Mr Suominen. "Then, using advanced sensor technology, material distribution in the hold can be analysed and a topographical map is created to ensure optimal unloading.

"As the crane starts unloading cargo from the ship, it constantly scans and analyses where cargo is in relation to the hold. The crane then grabs the cargo and unloads it at its shore-side. A ship can have two or three cranes operating simultaneously and parallel to each other."

Each crane pre-calculates suggested routes using MacGregor's command input shaping technology to optimise paths, ensure pendulum-free motion and minimise the total discharging time. The computer software not only takes into account the

The MacGregor cranes have now been fitted on board ESL's two new bulkers, Viikki and Haaga, deployed for service on the west coast of Finland in late 2018.

© MacGregor

topography of the ship's cargo hold to find the best lifting points, machine learning is also utilised, allowing the crane to quickly find the next target to grab.

An intelligent, self-learning algorithm automatically adjusts the system to ensure that the bucket is filled to an optimum level and not overloaded. Also, the auto-grip module readjusts lifting parameters when material properties change, automatically adjusting to switches between cargoes.

"The inside of a ship's hold is huge, which is why cranes need to be 'taught' the safest and most efficient unloading operational routes and how to move inside the cargo hold," explains Mr Suominen.

"If the crane stays in one place all the time, it will eventually reach the bottom of the hold at the same spot. The crane must therefore be able to look for cargo elsewhere in the hold. A human can see in one glance where the remaining cargo is, but for a machine, this must be taught. To do this, we use specially-developed machine vision software."

Mr Suominen notes that MacGregor has extensive knowledge in crane motion technology. Now in the D4V program, its experts have focused on defining the surface levels of the cargo in a ship's hold using new technologies, a specialist camera and an optical Lidar radar.

In programming, it is essential to define the areas where the crane cannot go. A crane must also be able to detect another crane to prevent the cranes from colliding with one another. In other words, there must be communication between cranes.

"This also allows us to optimise the movement of cranes to avoid unnecessary twitches and to make their movements smooth," he says.

The world's first autonomous discharging bulk cranes, developed during the D4V programme, have now reached their final development stages. The MacGregor cranes have now been fitted on board ESL's two new 25,532 dwt bulkers, Viikki and Haaga, deployed for service on the west coast of Finland in late 2018. The autonomous discharging features will soon be ready for commercial trials.

"The advantages of these cranes are irrefutable," says Mr Suominen. "They do not have to pause or stop, making unloading operations continuous. At the same time, the quality of work will reach new levels of consistency as unloading operations are no longer dependent on the skill of one crane operator.

"Many have expressed their interest in our autonomous discharging cranes and I foresee a significant future shift in traditional operating and working cultures in ports," Mr Suominen concludes.

SENSOR DATA FROM THE OPEN SEA INTO A CLOUD

When a ship is sailing in the open sea, up until now the transfer of large amounts of data has been difficult and costly, as connections have been dependent on radio waves and satellites.

Bandwidth in radio technology in the open sea is low and satellite connections expensive. Now Meyer's Turku shipyard has been experimenting with transmitting and storing sensor data using the data transfer solution by the Oulu-based KNL Networks. Data can then be stored into Wapice's IoT-Ticket storage service from all the seas in the world efficiently and affordably.

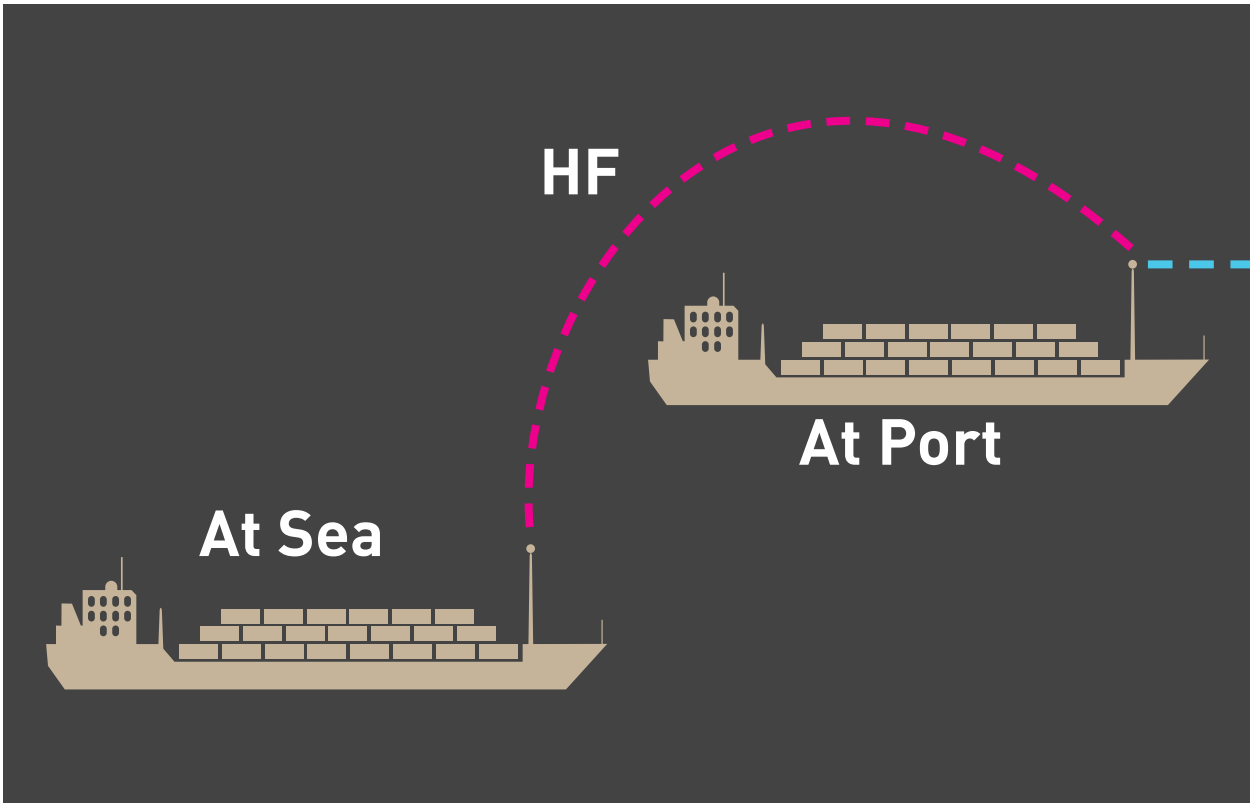
Cruise ships manufactured by Meyer include tens of thousands of devices that are used during the ship's operation. Meyer collects various data from the sensors in the ship's devices that is related to the ship's operations and performance.

"The idea is to utilise the data collected from the ships in real time or later. It is good to be able to collect usage data and analyse it. In the DIMECC D4V program, we have studied how data can be collected easily, securely and cost-efficiently. Another goal is to create a common point of connection for all who need it, which for its part will significantly improve the safety of ships," says **Kari Sillanpää**, the director responsible for product development and research at Meyer's Turku shipyard.

The solution by the Oulu-based KNL Networks allows global communication for ships using digital shortwave radio. The application combines HF radio with new innovations. In the open sea, KNL's radio solution utilises frequencies from under 30 megahertz all the way to 1.5 megahertz. Low frequencies enable very long connections up to 10,000 kilometres.

The idea is to have a network where all users transmit data. In fact, the quality of the network developed by KNL Networks improves with every new user, because it

"The data we receive allows us to provide even better services to ensure that ships are running as energy-efficiently as possible."

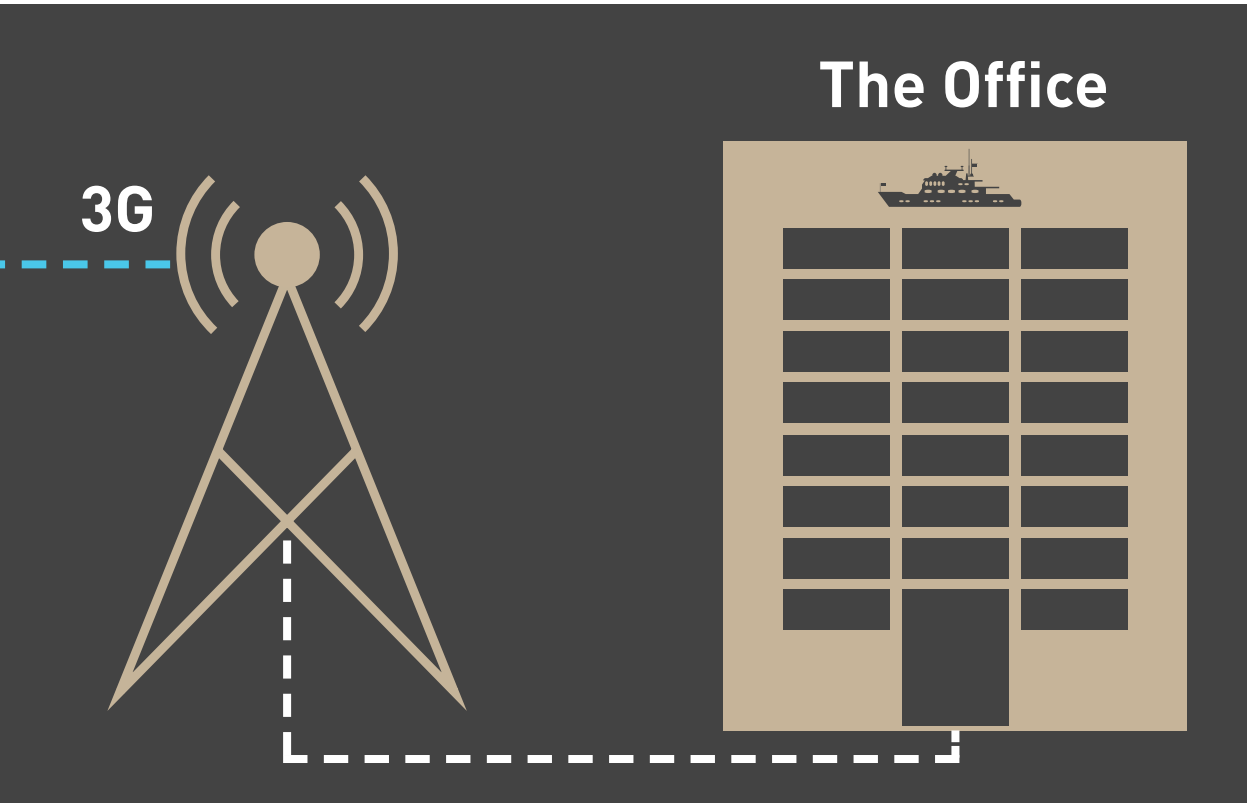


is a so-called MESH network where messages can travel along more than one path, and which also utilises several radio frequencies.

"Each ship creates a new potential point of connection, which improves the reliability of data transfer, while the simultaneous use of several bands improves transfer capacity."

KNL's solution can connect to another ship within 10,000 kilometres which, while in port or close to the coast, acts as an access point for ships sailing further away from the coast and provides a connection to a 3G/4G network. This allows data trans-

Mein Schiff 6 is the fourth in a series of ships build by Turku shipyard for TUI Cruises. Data was collected from this ship during the DIMECC D4V program.



fer from almost every corner of the world – even the polar circles that are outside the range of regular data transfer satellites.

"KNL offers a simple and efficient networking solution: data is transmitted from one ship to another, and from there, to a port and into a cloud. This solution is technically secure and safe in many ways."

Wapice's IoT-Ticket service stores data into a cloud, and the measured data can then, for example, be visualised into a format that is easy to understand and utilise.

"We started experimenting with KNL's system during the early stage of the D4V program. During the program, the system was developed further and Wapice was added in. Now we are able to collect and transmit data securely from a ship sailing in the open sea to an office. Data collection has been made easy. It does not affect the ship's operation and it cannot be used to hack into the ship's systems. In information security-related matters, we have also collaborated with F-Secure."

Pilot tests have already confirmed the functionality of the system, and Meyer's office can get real-time data about cruise ships.

"Cruise ships are complex systems, and their energy needs change constantly depending on whether the ship is moving, what sort of environment the ship is moving in and what operations are active on the ship. The data we receive allows us to provide even better services to ensure that ships are running as energy-efficiently as possible."

Since the environment of a ship is constantly changing dynamically, Meyer uses collected data for simulation models, for the ships' so-called virtual twins. This provides a more accurate picture of the situation on the ship, and ship operations can be adapted to changing environments in real time.

Sillanpää says that in the future, the goal is to develop data collection and use and the ability to utilise virtual models.

"This way, it is easy for an even larger number of device and system providers – or entirely new operators – to join in and start using the data available, both in their own development work and for providing new services."

A SIMULATION MODEL FOR CRUISE SHIP ENERGY FLOWS IMPROVES COST-EFFICIENCY

By simulating the energy flows on a cruise ship, it is possible to constantly improve the ship's energy efficiency. It also facilitates the testing of new systems and equipment and accelerates their deployment, which decreases costs. In the DIMECC D4V program, Meyer developed a software that is suitable for the simulation of energy flows, and started thinking also a ship's internal logistics flow simulator.

The goal of Meyer's Turku shipyard is to be a forerunner in the construction of the world's most energy-efficient ships. Energy efficiency is improved by using computer simulation that helps discover the best technical solutions. Data about the ship's operation is utilised in simulations when new ships are designed. To improve energy efficiency, data is collected about things such as the ship's fuel consumption, the operation of engines and generators, exhaust gases and cooling systems.

"The things that can be done easily to improve energy efficiency have already been done, however," says **Kari Sillanpää**, the director responsible for product development and research at Meyer's Turku shipyard.

"When the complex systems of a ship are under improvement, the only way to test the usability of new technologies is simulation. Only simulation software is capable of testing new equipment and various optimisation solutions thoroughly enough."

As an example, Sillanpää mentions the utilisation of waste heat. Although waste heat is utilised in various ways, in some situations more waste heat is produced than is being used. Steam produced by an exhaust gas boiler is used for heating, but the amount may be too large for the ship's laundry, for example. Simulation allows the calculation of what else it could be used for under changing conditions and what would be the optimal configuration under the intended operating conditions.

One option could be the addition of a steam turbine or ORC device. During the ORC process (Organic Rankine Cycle), organic matter circulating inside a closed piping system is vaporised using heat, converted into electricity in a turbine generator and returned to circulation after condensation.

"Simulation allows the calculation of the optimal amount of heat for various needs and whether the remaining waste heat can be used for things like electricity generation. When energy needs and operating profiles have been correctly defined in the simulation, we get a credible prediction of how a new device will affect the ship's energy needs."

"Simulations can facilitate the entry of new and different kinds of operators into the market."

The purchasing price of devices can raise the threshold for adopting new technology. According to Sillanpää, simulation helps predict how much a new device will improve energy efficiency and what the device's payback period will be.

"Simulation enables reliable predictions of how much a new device can help save costs later, for example. This means that simulations can facilitate the entry of new and different kinds of operators into the market."

According to Sillanpää, Apros, developed by VTT and Fortum, has proven to be the most suitable software for simulating the energy flows of ship systems.

"The software is suitable both for physically accurate simulations of individual device components and for very broad simulations where a ship's systems are processed in a simpler way to speed up computation time."

The Apros software has been further developed in collaboration with VTT to make it better suitable for the needs of the marine industry. Development of the software has continued in the DIMECC D4V program. The software also plays a key role when data collected from a ship's sensors is transmitted from the ship to the office for analysis. A key question for further development is how dynamic simulation can be used for improving the efficiency of the operations of a ship at sea.

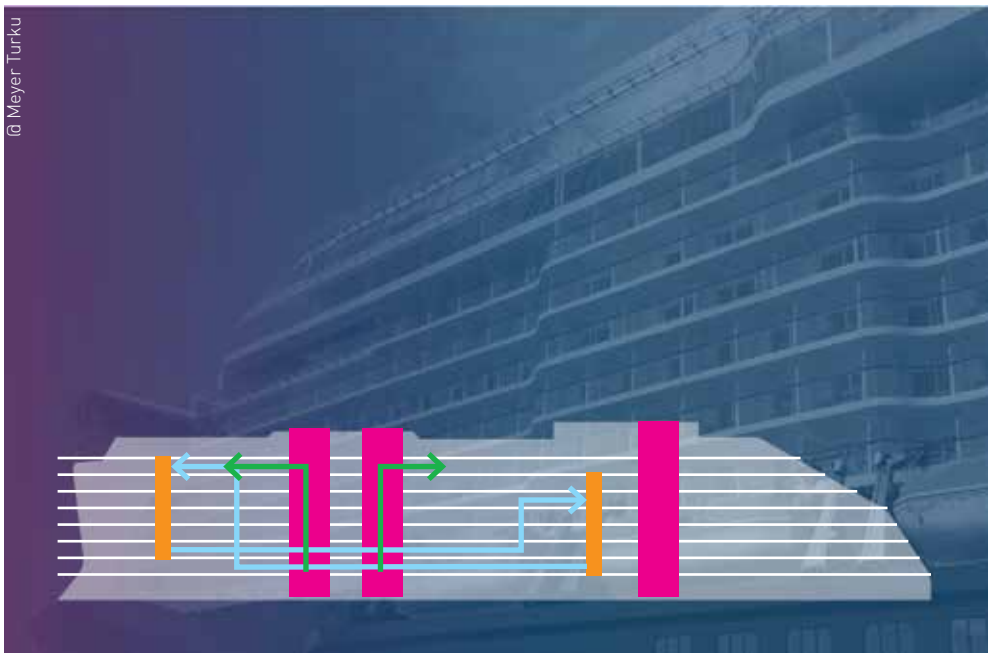
Oasis of the Seas in the Caribbean Sea.

Sillanpää reminds that a cruise ship's energy needs vary constantly depending on the environmental conditions and the time of the day. The greatest variable is propulsion: whether the speed at night will be higher or lower depends on how far the next port is.

"The software allows the calculation of a ship's annual operating profile. When you look at the data collected about the operation of a single ship, the changes in energy needs are huge. The variation can be between 10% and 90% several times a day, and smaller variation is constant. The next development step is linking automated, smart optimisation into the process to make it even easier to discover the best solutions for different operating conditions."

Meyer Turku has now started surveying new possibilities for simulation. Besides energy flows, they include a ship's logistics flows.

"A cruise ship is a pretty complex facility. It is a system the size of a small town. The ship's design must take into account various data flows: storage spaces, passageways, service facilities and transportation of people and things," says Sillanpää.



Passenger ship flow simulation. Depending on design of a ship, each vessel has a unique flow chart to which needs to be defined in early stages of ship design.

The first Oasis class ship completed at the Turku shipyard in 2009, Oasis of the Seas, is a good example of a ship that is a huge community where people and things move around as if they were in a town. This ship and its sister ships are the largest cruise ships in the world. The ship has more than 20 decks, about 2,700 passenger cabins, 19 restaurants, a large spa and shops. There is even a bar-restaurant that moves between three decks like an elevator. There are 5,400 passengers and 2,150 members of crew. 200,000 meals are served during a one-week cruise. There are 21 pantries, and ingredients have been packed efficiently, utilising all available space. Fruit and vegetables alone must be packed so that some of them can be used immediately while others are allowed to ripen in the pantries and are consumed during the latter half of the trip.

"Because cruise ships have many restaurants, the simulation model must also take into account the logistics flows from ship kitchens to the dining rooms and back. The retrieval of an ingredient and its storage in pantry areas at different restaurants is also included in the model," says Sillanpää.

The simulation tool is much needed, for depending on the customer, cruise ships built by Meyer Turku also include new functionalities and solutions. New data flows can also be added easily to the simulation model.

"New technologies that are simulated and whose effects are surveyed may include the automatic transportation of laundry or shop products, various storage solutions or ensuring even better accessibility for people through things like horizontal transportation," Sillanpää emphasises.

There are many logistical challenges on a huge cruise ship. According to Sillanpää, one common example is the sun deck. While lying on the sun deck, few people think about the way towels are brought out and collected.

"When there are hundreds of people on the sun deck at the same time and they all get towels, you're going to end up with a pretty huge towel pile."

There are several shops on the ship with plenty of goods. If there are hundreds of people in the shop at the same time and they all have purchases, how can they fit into the hallways? How do crowds of people scatter inside the ship at the end of a theatre performance? How to use elevators when the ship arrives in port?

According to Sillanpää, the simulation model is one way of making it easier to ensure that passengers get an even better holiday experience.

PLANNING FOR A NEW MARITIME ECOSYSTEM WITH EDGE COMPUTING

Ericsson has been developing different Internet of Things (IoT) solutions.

During the D4V program, it sought new solutions to combine different players into the ecosystems, using cloud, IoT and edge computing. For example, during the operational phase, an autonomous ship is under the control of a fleet operator, but multiple system users can use its sensors and data. This would mean a new data-sharing ecosystem in the maritime industry.

Autonomous sailing is creating a new ecosystem, and new technologies are changing the ecosystem. Also, new players are coming, such as technology and service providers.

This means that the maritime, logistics and manufacturing industry are modifying the ecosystem into a more horizontal structure. So, what technology is needed for the ecosystem?

"Daily internet connectivity is paradigm in cloud computing even in data processing, but not fully feasible on ships. There are challenges related to latency, unreliable satellite connection, and limited mobile connections. However, internet connectivity is just one aspect of the problem. There are other aspects to consider, such as

processing capacity and interoperability between vendors," says senior researcher **Edgar Ramos** from Ericsson Finland.

During the D4V-program, Ericsson has been developing a distributed cloud solution that can bring connectivity and different platforms to IoT. Ships can use data storage and data sharing provided by the distributed cloud.

"The cloud system can use edge computing to synchronise data."

In edge computing, the computation is normally performed on distributed smart device nodes. "Edge" refers to the geographic distribution of computing nodes. Edge is usually located in places where there is limited or no connectivity. These places can be, for example, ships. Autonomous shipping is a good case for using edge computing. An ecosystem based on service providers in a ship environment and with limited connectivity can be created via edge computing.

"We have a demonstrator where, e.g., a miniature autonomous ship has an autonomous edge computing environment, where we run ship-control software, as well as machine learning functions to optimise navigation and docking." Says senior researcher Jimmy Kjällman from Ericsson.

"The cloud system can use edge computing to synchronise data."

According to Kjällman, good examples of applications can be cargo-monitoring software, data sharing platform components, or software that monitors, controls, and optimises the autonomous ship's systems.

The goal is to also create a full life-cycle management system on ships, based on specific components and services. Life-cycle management means configuring, updating and decommissioning services and applications. This could mean providing Netflix or similar entertainment on ships without internet.

"We have another demo related to using edge resources for improving video processing of a video stream depending of the load and connectivity situation", says Ramos.

Life-cycle management and data sharing can easily be established on ships since the computing capacity and even data centers are already present on some decks. The system includes autonomous local environments on ships, which are part of the distributed cloud. It has shared multi-tenant infrastructure, so that different players can participate. It is structured in such way that each one need not bring their own separate computing infrastructure. It has secure isolation capabilities both at the edge and centrally.

"For example, some parts of a distributed data processing service can be deployed to the autonomous edge computing environment, some, at local clouds in harbours, and some in central data centers. In our machine learning case, we can utilise all these. We use local computing with the information and resources available on the ship while at sea, and use additional information and resources in harbour clouds and central clouds when the ship is close to shore and while docking. We could also synchronise information with, e.g., on-premise clouds. The life-cycle management manages all the distributed microservices related to a service, and configures the networking between them across domains", says Jimmy Kjällman.

According to Edgar Ramos, in the future, IoT will become a prominent part of shipping and manufacturing,

"At the moment IoT has silos, and the ecosystem is too vertical.

We should develop solutions for scaling different cases and we need interoperations to connect things horizontally. Added value in autonomous shipping can be found in manufacturing and logistics."

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DATA-SECURELY AT SEA

The maritime industry in Finland has quickly adopted new digital technologies, such as the Internet of Things and cloud services for devices.

When an increasing number of ship devices and systems connect to data networks, ships become desirable targets for cybercrime. It opens up new opportunities for criminals seeking commercial profit and deliberate damage. In the future, they will be able to take control of an entire ship instead of a computer. In the D4V program, F-Secure has participated in supporting the automatisation of shipping and its data security by utilising things such as its data security work experiences in the aviation industry.

F-Secure's core business has been the protection of terminal devices. In recent years, the company has been expanding its operation into the prevention and detection of targeted attacks at businesses.

"In the D4V program, it has been our goal to be part of spearheading the automation in shipping and to understand the needs of the maritime industry in data security," says **Markku Kutvonen**, the F-Secure director responsible for external collaboration.

The DIMECC's D4V program has involved collaboration with Rolls-Royce's Turku research center and Meyer's Turku shipyard. Since F-Secure products can be scaled for different needs, they also help protect the systems of the maritime industry. Rolls-Royce's Turku research center designs remotely controlled and autonomous ships. In the D4V program, Meyer has experimented with transmitting data from cruise ship sensors securely from the open sea to an office and storing it into a cloud.

Ship devices connected to data networks must be protected

The DIMECC's D4V program is a good example of Finnish businesses and research institutions being among the first to develop security solutions for autonomous shipping," says Senior Manager **Marko Komssi** from F-Secure.

"It has been our goal to be part of spearheading the automation in shipping and to understand the needs of the maritime industry in data security."

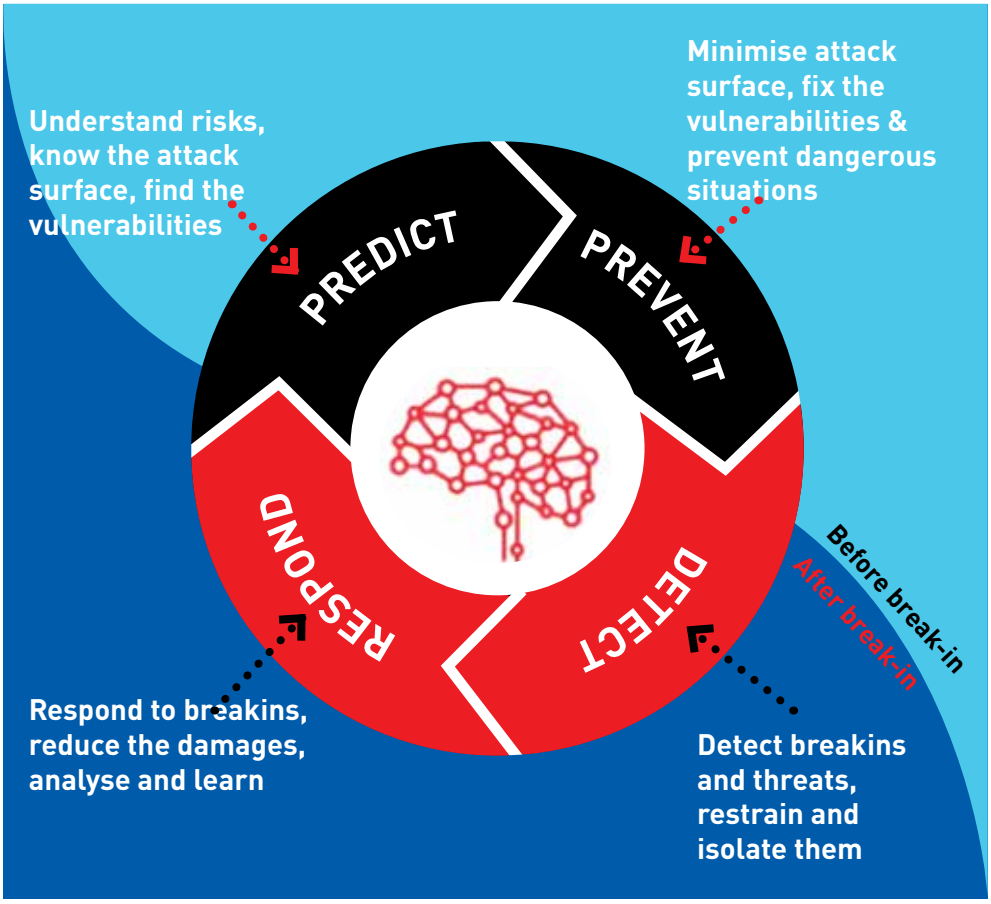
Ships have traditionally been protected from things like the physical attacks of pirates using arms. In the future, attacks can be launched remotely through data networks or internally by installing malware into a ship's IT systems from a flash drive, for example.

"The level of system automation will improve when actuators and sensors are connected to a network. Ship engines produce data that is analysed in real time, logistics is controlled by artificial intelligence and ships begin to observe their environment even better. When ships are connected to the Internet, our task is to identify new targets for attacks as the number of device communication interfaces increases. Data security must be in order when devices communicate with each other, the operator, the manufacturer and maintenance. Attack paths are sought through threat modelling and risk assesment," says Markku Kutvonen.

Besides engines, ships also include many different critical systems whose state is monitored through sensors. They provide data about when the machinery has had maintenance, how the propulsion and engines are working, information about ship movements and location and how the audio-visual equipment, such as the video cameras and microphones on the bridge or distance measurement are working. Other things that need securing include communications systems and the software used by the shipping company and ports.

An internal attack could be caused by a person who has entered the ship, has access to the ship's intranet and installs malware or an infected device or sensor. Firmware could also be the target of an attack. This embedded software is responsible for a device's basic functionalities. Device updating methods must be secure. The updating of traditional on-board computers, for example, may only be done on-site at special maintenance. An internal attack may target ships' location systems. A ship's GPS signal may be disrupted by installing another GPS transmitter on board that will increase its strength gradually, so it won't be detected. The transmitter may also block the GPS signal or send false location coordinates.

"We no longer connect devices with cables. Instead, ships have wireless networks and Bluetooth connections. This means that any passenger could be a threat," says Kutvonen.



"Criminals have innovative skills, money and time. In risk management, it's important to ask what the motives for an attack could be. Are the interests political or financial? Terrorism or money? It's currently possible to hijack a PC through a data network and send a ransomware note; in the future, someone could even attempt to hijack an entire ship. A ship is a big weapon in itself. Fortunately, cybersecurity helps prevent even physical attacks, so an oil tanker can't be hijacked and crashed into the port of Helsinki," Kutvonen ponders.

Artificial intelligence helps predict and act

In the future, new information security threats require not only prevention, but also constant monitoring of systems for predicting attacks. By teaching artificial intelligence, incoming attacks can be identified before any damage has been done.

Currently, we are building locks, but in the future during the ship design stage, information security solutions must be able to identify attack risks in advance.

"Ship systems must be able to identify attacks and raise an alarm already when someone is only planning a security attack. Based on data, artificial intelligence may also suggest what should be done next to block the attack."

"Artificial intelligence will notice if something unusual is happening somewhere. Unusual activity may include someone logging in using an administrator ID or plugging an unidentified flash drive into a computer. In other words, the system offers protection and guidance."

FOR MORE INFORMATION:
Cybersecurity Attacks and Defences for Unmanned Smart Ships
Bilhanan Silverajan (Tampere University of Technology),
Mert Ocak (Ericsson, Finland), Benjamin Nagel (F-Secure)

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DIGITAL IDENTITY FOR STEEL

In the DIMECC D4V program, the steel company SSAB developed smart steel. SmartSteel gives a steel product a digital identity. Folders and PDF files are no longer needed; the customer just needs use their smartphone to scan an identifier painted onto the steel to obtain information and instructions related to the product.

"The application enables us to provide the customer with information about the behavior of steel when it is processed and other information about the product."

The SmartSteel application allows a customer to identify products, check the properties of the materials, download material certificates and send feedback. Automatic product identification brings huge savings. According to **Niko Korte**, Senior Manager Digital Business Development at SSAB, a customer needs to be able to quickly itemise the products they have ordered. This reduces errors in the delivery of goods. Until now, logging the arrival of incoming goods has been done manually. The product number is logged and entered into the customer's own management system.

"The most common problem is finding the goods. There is no information about how many steel sheets there are in stock and where they are. In the worst case, the wrong product is in the wrong place, which is both a quality and a safety risk. The SmartSteel application is extremely useful because it reduces manual work and errors in the production chain."

In addition to the product getting quickly to the right place, the customer is able to see product information.

"We offer the customer tools for facilitating their work. The application enables us to provide the customer with information about the behavior of steel when it is processed and other information about the product. What grade of steel are we dealing with? How should it be processed? This is the core idea of smart steel. Now that we are able to link the product to the customer, we can be sure of safely sending the customer information about the product."

A technology was developed during the DIMECC's D4V program that, using machine vision, allows recognition of a product in the customer's premises. The D4V program involved things like the development of image recognition using neural networks. In practice, steel sheets are identified through image recognition. The numbers and characters are read from the surface of the steel using machine vision.

The product's manufacturing ID has been painted onto the steel sheet. A smartphone will use the physical shape of the number's stamp area to identify which line and which mill the product came from.

"It can identify, for example, that this product is from the Raahe plate mill and read the product ID from the first six characters in the second row."

The application reads the characters and converts them into machine-readable numbers used for finding product information in SSAB's database.

"Customers don't necessarily operate based on our product ID. They have their own codes linking the product to the purchase order. Nor do customers use our purchase order to find information in our database. This can now be done automatically."

According to Korte, the main idea is the utilization of data between the manufacturer and the customer.

"Data will help steel will go through the customer's production facility faster and more safely."

There are many possibilities for utilising data.

"Looking ahead, we're planning to add sustainability information to products. Information such as the percentage of recycled steel in a product or the product's carbon footprint."

In the DIMECC's D4V program, SSAB's application was developed together with Taito United, Enfo and Siili Solutions. Taito United focused on neural networks. Product information can now be studied by using a smartphone. Product identification and scanning were tested with Enfo at a Meyer Turku shipyard. Interface technology was developed with Siili Solutions. In the future, the intention is to create a link between SSAB's cloud service and the customer's data system.

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The product's manufacturing ID has been painted onto the steel sheet. A smartphone will use the physical shape of the number's stamp area to identify which line and which mill the product came from.

AGILE MANUFACTURING IN ECOSYSTEMS AND VIRTUAL FACTORIES

In the DIMECC D4V program, Fastems has developed methods for agile manufacturing. When data is shared and utilised diversely, manufacturing will be able to respond to the modern consumer's needs for more personalised and higher-quality products.

"The future twin of the control system runs in a cloud during design, and together with the customer we can review how new software features are working."

Fastems is a leading independent manufacturer of factory automation systems. The company's goal is to help its customers succeed by the means of automation. Fastems is known for flexible manufacturing systems (FMS), robotics-based automation, manufacturing software solutions and lifecycle services. In the D4Value program, Fastems has focused on enabling agile manufacturing brought to the manufacturing industry by digitalisation on all its levels.

"Our starting point has been good customer understanding. It has been important to find out how customers see the opportunities and challenges of digitalisation in the manufacturing industry. This has been our basis for steering our digital strategy. In this work, we have received valuable sparring from our research partners, which have included MIT (Massachusetts Institute of Technology), internationally known for its top research in the field," says **Harri Nieminen**, head of innovation development and research at Fastems.

Nieminen believes that the manufacturing industry will significantly benefit from data sharing and rising agile ecosystems.

"Manufacturing always takes place in networks. The dream of economically feasible manufacturing of lot-size-one can only be realised after the data created by different players in the network is made visible and shared in the manufacturing ecosystem. Shared data allows the agility of the network to grow to a new level and manufacturing can be better managed as a whole. On the other hand, this also enables the creation of entirely new businesses that have never been seen before."

In the D4V program, Fastems has created models of ecosystems together with Aalto University, the University of Turku and the Tampere University of Technology. This has also involved conceptualisation of the novel service businesses built around shared data and ecosystems. In the future, this could allow members of the ecosystem to sell their surplus materials and share resources, for example.

Harri Nieminen also talks about an Agile Manufacturing System (AMS), which is a step towards economically feasible manufacturing of lot-size-one on a factory level.

"The complexity of manufacturing operations is ever increasing. Customers demand faster delivery times for even higher-quality and more personalised products. This requires a new level of agility from manufacturing and its systems. This challenge can be answered through the means of the Agile Manufacturing System conceptualised during the program."

At the core is manufacturing intelligence, which directs manufacturing in an even more agile manner. AMS links seamlessly into manufacturing as a whole, quickly adapts to changing customer needs and is flexible in terms of integration of new resources. AMS is reliable and has good fault resilience.

In the D4V program, Fastems studied the possibilities of improving the efficiency of manufacturing systems through data analytics. By the means of the data created through the interaction between the system and the user and data analytics, it is possible to find out how the system is used in real life and what kinds of challenges customers encounter in their everyday operations.

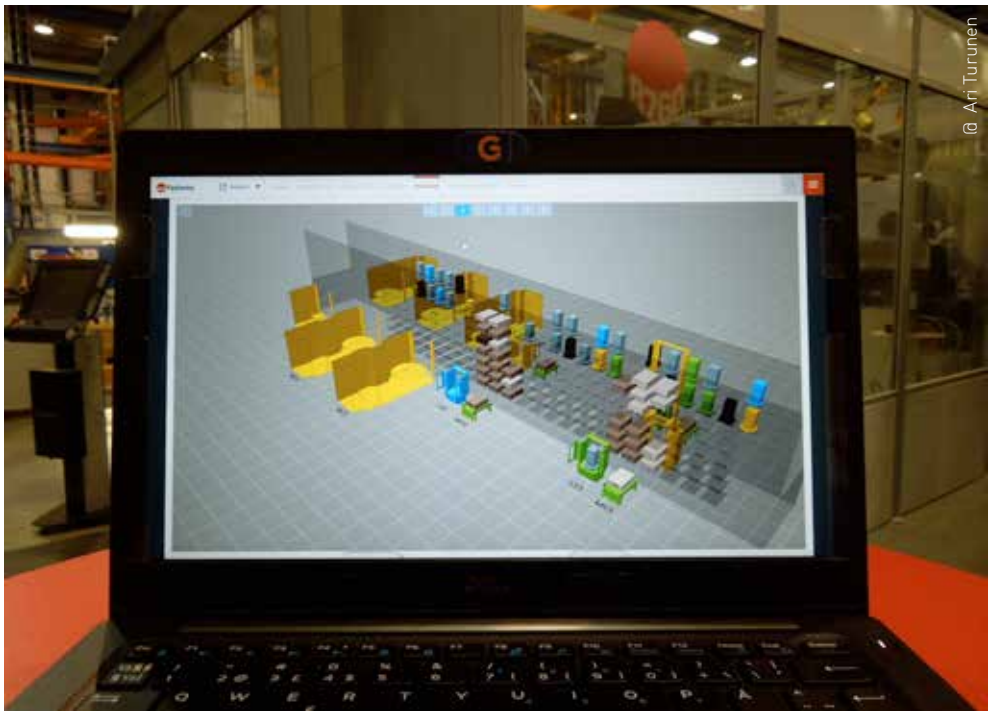
Flexible Manufacturing System for training. Two loading stations: the left station is for the materials, and the right station is for the loading operations.

"Analysing the data accumulated by the system enables services through which the customer is able to not only maintain the level of performance in manufacturing, but most importantly, to significantly increase it."

The idea of a digital twin is that for the manufacturing system sitting on the factory floor, there is a digital version that includes all necessary information about its physical counterpart. The digital twin allows designers and system users to test different solutions quickly before proceeding from design to practice.

"During the program, we further developed the concept of a Virtual Factory and also piloted partial solutions. Virtual Factory creates many new opportunities that

FMS visualisation of the digital twin in the learning environment.



extend beyond the system lifecycle, from participatory system design to training, parallel simulation of manufacturing and change management."

The piloted partial solutions of Virtual Factory are utilised in training and participatory system development and commissioning.

"The future twin of the control system runs in a cloud during design, and together with the customer we can review how new software features are working. Similarly, the customer will be able to enter pre-production data about manufacturing into the control system even before system installation. This will decrease commissioning time significantly."

In the future, simulations allow factory manufacturing processes to be optimised even more efficiently.

SCIENTIFIC ARTICLES

published by the DIMECC D4V 2017–2018

- **Exploring the Interplay of Mindset and Abilities at Multiple Organizational Interfaces**
- **Material Intelligence:**
  Cross-Organizational Collaboration Driven by Detailed Material Data
- **Design Science Research Contributions: Finding a Balance between Artifact and Theory**
- **Parallel Coordinate Plots for Neighbor Retrieval**
- **Business Model Innovation in European SMEs – Descriptive analysis of quantitative survey and case survey data**
- **Means to Survive Disruption: Business Model Innovation and Strategic Continuity Management?**
- **Digital Practice Misfits: Beyond IT Artifacts**
- **From strategic goals to business model innovation paths: an exploratory study**
- **Managing business and innovation networks – From strategic nets to business fields and ecosystems**
- **Selling Solutions by Selling Value**
- **Design Science Research Contributions: Finding a Balance between Artifact and Theory**
- **Networks, business models, and competitiveness in small Finnish firms**
- **From the profit of one toward benefitting many – Crafting a vision of shared value creation**
- **A Value Proposition Development Framework for Industrial Service**
- **Overcoming Institutional and Capability Barriers to Smart Services**
- **Prospects of CPQ: evolving toward industry platforms**
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  A micro-foundations perspective
- **Usage Data Analytics for Human-Machine Interactions with Flexible Manufacturing Systems: Opportunities and Challenges**
- **Cognitive Mimetics for Designing Intelligent Technologies**
- **Virtual Environment for Training Autonomous Vehicles**
- **Strategic Positioning in Big Data Utilization: Towards a Conceptual Framework**
- **Customer participation in knowledge intensive business services:**
  Perceived value outcomes from a dyadic perspective

Exploring the Interplay of Mindset and Abilities at Multiple Organizational Interfaces

This article explores organizational change driven by the digitalization of services in technology firms. The change offers exciting opportunities for improved value creation, but challenges the prevailing business models, and requires fundamental changes in resource and capability portfolios as well as their integration within business ecosystems. The study investigates the change at the institutional and capability realms at internal and external interfaces. This study is conducted as a multi-case study among seven globally operating firms. We observe their transition toward digitally enabled smart services and value-based business logic. Our findings identify three groups of barriers to change, causing internal and external mismatches of mindset and abilities. The study contributes to the organizational change literature by deriving an analytical framework for understanding the interconnected change of the mindset and abilities, as well as the alignment of those two. We suggest that to capitalize on the emerging opportunities related to the digitalization of services, firms may need to disrupt the status quo, and to reconstruct a more competitive internal and external configuration of abilities for service-based business models.

Pekka Töytäri (Aalto University), Taija Turunen (Aalto University), Maximilian Klein (University of St. Gallen), Ville Eloranta (Aalto University), Sebastian Biehl (University of St. Gallen), Risto Rajala (Aalto University): **Exploring the Interplay of Mindset and Abilities at Multiple Organizational Interfaces**

Academy of Management Proceedings, Vol. 2017, No. 1
https://doi.org/10.5465/ambpp.2017.16710abstract

Material Intelligence: Cross-Organizational Collaboration Driven by Detailed Material Data

The application of the Internet of Things (IoT) technologies has the potential to reshape interorganizational collaboration across industries. This study explores the influences of the use of IoT for information sharing in the steel industry networks. Shared data may have multiple uses, including optimization, integration, automatization, and adaptation of objects in their environments. To date, research on IoT has mainly proposed its use in independent nodes and clusters possessing excessive data from their own actions. Conversely, our study emphasizes the benefits that accrue from intensified collaboration. Our findings emphasize that IoT enabled material intelligence can restructure the existing steel industry networks. This can be achieved by bridging the structural holes in the inter-organizational networks.

Esko Hakanen, Ville Eloranta, Pekka Töytäri, Risto Rajala, Taija Turunen (Aalto University): **Material Intelligence: Cross-Organizational Collaboration Driven by Detailed Material Data**

Proceedings of the 50th Hawaii International Conference on System Sciences, 2017
http://hdl.handle.net/10125/41192

Design Science Research Contributions: Finding a Balance between Artifact and Theory

With the rising interest in Design Science Research (DSR), it is crucial to engage in the ongoing debate on what constitutes an acceptable contribution for publishing DSR - the design artifact, the design theory, or both. In this editorial, we provide some constructive guidance across different positioning statements with actionable recommendations for DSR authors and reviewers. We expect this editorial to serve as a foundational step towards clarifying misconceptions about DSR contributions and to pave the way for the acceptance of more DSR papers to top IS journals.

Richard Baskerville (Georgia State University), Abayomi Baiyere (University of Turku), Shirley Gregor (Australian National University), Alan Hevner (University of South Florida), Matti Rossi (Aalto University): **Design Science Research Contributions: Finding a Balance between Artifact and Theory**

Journal of the Association for Information Systems: Vol. 19 : Iss. 5 , Article 3.
https://aisel.aisnet.org/jais/vol19/iss5/3

Parallel Coordinate Plots for Neighbor Retrieval

Parallel Coordinate Plots (PCPs) are a prominent approach to visualize the full feature set of high-dimensional vectorial data, either standalone or complementing other visualizations like scatter plots. Optimization of PCPs has concentrated on ordering and positioning of the coordinate axes based on various statistical criteria. We introduce a new method to construct PCPs that are directly optimized to support a common data analysis task: analyzing neighborhood relationships of data items within each coordinate axis and across the axes. We optimize PCPs on 1D lines or 2D planes for accurate viewing of neighborhood relationships among data items, measured as an information retrieval task. Both the similarity measurement between axes and the axis positions are directly optimized for accurate neighbor retrieval. The resulting method, called Parallel Coordinate Plots for Neighbor Retrieval (PCP-NR), achieves better information retrieval performance than traditional PCPs in experiments.

Jaakko Peltonen (Aalto University) and **Ziyuan Lin** (University of Tampere): **Parallel Coordinate Plots for Neighbor Retrieval**. In Proceedings of the 12th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications - Volume 3: IVAPP, (VISIGRAPP 2017)

DOI:10.5220/0006097400400051

Business Model Innovation in European SMEs – Descriptive analysis of quantitative survey and case survey data

In this paper we analyse Business Model Innovation (BMI) in European micro, small and medium sized enterprises (SME). We present descriptive findings from our quantitative survey and qualitative case survey on how SMEs are innovating their Business Models. Our survey indicates that 37% of European SMEs innovate their Business Model. We found some differences in BMI depending on the age and industry sectors. We also

describe the changes the SMEs make in differing Business Model components when they are improving their Business Model.

Marikka Heikkilä (University of Turku) & Harry Bouwman (Åbo Akademi University): **Business Model Innovation in European SMEs - Descriptive analysis of quantitative survey and case survey data**

Presented at the 31st Bled eConference: Digital Transformation – From Connecting Things to Transforming Ou Connecting Things to Transforming Our Lives, June 18 – 21, 2017, Bled, Slovenia https://doi.org/10.18690/978-961-286-170-4.38

Means to Survive Disruption: Business Model Innovation and Strategic Continuity Management?

Advances in Information Technology provide opportunities for totally new business. However, we are facing not only growing number of new ventures, but increasing re-structuring of existing businesses. This can be perceived e.g. in shortening life-cycles of the companies. The restructuration and birth of new companies means changing or even disrupting existing businesses. Therefore, companies, regardless of their maturity, should be prepared to evaluate these threats and opportunities actively. Against this backdrop, we suggest to combine business modelling with systematic Business Continuity Management. We discuss the two approaches and their usefulness under different circumstances and illustrate their use when implementable, rapid reaction to changes is required, such as in industry restrucutration, or business merging and reorganization. We coin this combination as Strategic Busiess Continuity Management.

Jukka Heikkilä (University of Turku), Marikka Heikkilä (University of Turku), Marko Niemimaa (University of Jyväskylä), & Jonna Järveläinen (University of Jyväskylä): Means to Survive Disruption: **Business Model Innovation and Strategic Continuity Management?**

Presented at the 31st Bled eConference: Digital Transformation – From Connecting Things to Transforming Ou Connecting Things to Transforming Our Lives, June 18 – 21, 2017, Bled, Slovenia https://doi.org/10.18690/978-961-286-170-4.39

Digital Practice Misfits: Beyond IT Artifacts

Although 'digital transformation' is increasingly relevant for contemporary organizations, many struggle to achieve it. Drawing on literature on misfit, specifically the notion of impositions, we uncover how introduction of novel digital practices impede digital transformation. We problematize the focus of prior impositions literature on IT-artifacts and propose that digital practices lead to impositions that are rooted in organizational structures. We develop a process model suggesting that digital practices – practices driven by a digital transformation agenda – are equally potent sources of misfits and are particularly pertinent in the digital transformation of today's organizations. We develop this argument using two longitudinal cases covering a total of 31 months in a hospital and a manufacturing company. We conclude with theoretical implications that advance digital practices as a viable lens for theorizing about misfits in organizations, and highlight practical implications that emphasize on how organizations can better grapple with misfits and digital transformation.

Baiyere, A. (University of Turku), Cha, J. (University of Manchester), Ologeanu-Taddei, R. (University of Montpellier), Wessel, L. (Freie Universität Berlin), & Jensen, T. B. (Copenhagen Business School): **Digital Practice Misfits: Beyond IT Artifacts**

In ICIS 2017 Proceedings (pp. 2227). Association for Information Systems. AIS Electronic Library (AISeL).
https://aisel.aisnet.org/icis2017/Paper-a-thon/Presentations/3/

From strategic goals to business model innovation paths: an exploratory study

The purpose of this paper is to analyse how different strategic goals of (micro-, small- and medium-sized firms=SMEs) relate to the business model innovation (BMI) paths that SMEs take when improving their business. The authors conducted 11 in-depth case studies involving SMEs innovating their business models (BMs). The authors found evidence that strategic goals of SMEs (start new business, growth and profitability) lead them to alternative innovation path in terms of BM components affected. Growth seekers start from the right-hand side of a BM Canvas, while profitability seekers start from the back end, the left side of a Canvas; and new businesses adopt a cyclical approach considering BM components in turn, while at the same time redesigning and testing the BM. The findings of this study also indicate that all three paths gradually lead to improvement in several BM components.

Findings indicate that a strategic management view in which strategic goals define BMI also applies to SMEs. The distinctive BMI paths that the authors identified provide evidence to suggest that, although the SMEs may not have an explicitly formulated strategy, their strategic goals determine the type of improvements they make to their BM. All three SME groups started their improvements from different BM components and changed several elements in their BMs in a specific order, forming distinctive BMI paths. Finally, to understand the BMI in SMEs better, more research is needed into BMI processes and into the way BMI is managed in SMEs.

The findings of this study help SMEs to anticipate the next steps in their path towards an improved BM. By mirroring their approach to the BMI paths, they can better manage their BM makeover process and focus on their innovation activities. For providers of BMI tools and methods, the study indicates which SME innovation tasks could be supported by tools and how the tools should be aligned with the BMI paths.

BMI is attracting growing attention in both research and practice. However, knowledge concerning BMI in SMEs is limited. The authors contributed to BMI research by focussing on the BMI paths of SMEs, i.e. the often sequential, non-linear and iterative steps taken to improve the business by making changes to specific BM components.

Marikka Heikkilä (University of Turku), Harry Bouwman (Åbo Akademi University), Jukka Heikkilä (University of Turku): From strategic goals to business model innovation paths: an exploratory study

Journal of Small Business and Enterprise Development, Vol. 25 Issue: 1, pp.107-128
https://doi.org/10.1108/JSBED-03-2017-0097

Managing business and innovation networks – From strategic nets to business fields and ecosystems

This article introduces the Special Issue of Managing Business and Innovation Networks and makes an independent contribution to the advancement of network management research. The study has three ambitious goals. First, it evaluates the main developments in network management research from 2000 to 2016, focusing on disciplinary openings. Second, it specifies the contributions of recent domain extensions (business fields, ecosystems, platform networks) to network management, and clarifies the role of networks and network management in these domains. Third, it proposes a general theory of network management based on the past 20 years of research in the field and the contributions of SI articles. The theory explains how the factors at three contextual levels – environment, network and actor – influence network management activities, forming patterns of management based on activity configurations. The framework consolidates our fragmented knowledge on network management and paves the way for more advanced research and management. We conclude with suggestions for future research.

Kristian Möller (Aalto University), Aino Halinen (University of Turku): **Managing business and innovation networks—From strategic nets to business fields and ecosystems**

Industrial Marketing Management, Volume 67, November 2017, Pages 5-22
https://doi.org/10.1016/j.indmarman.2017.09.018

Selling Solutions by Selling Value

Selling new innovative services and solutions demands a proactive and customer value-focused sales approach, and new capabilities and resources to support the approach. Firms find the transformation challenging and lack tools to succeed. In this chapter, I discuss the internal and external challenges of implementing value-based solution selling, illustrate the involved processes and their connections, and explicate the key activities of the value-based solution selling process. This chapter embeds the sales transformation into a broader change of business logic, analyzes the value-based solution selling from the value proposition communication and differentiation method, and provides a managerially relevant framework to guide the implementation.

Pekka Töytäri (Aalto University): **Selling Solutions by Selling Value**

In book: Practices and Tools for Servitization, Managing Service Transition (eds. Marko Kohtamäki, Tim Baines, Rodrigo Rabetino, Ali Z. Bigdeli), Springer, 2017 pp.269-289
https://doi.org/10.1007/978-3-319-76517-4_15

Design Science Research Contributions: Finding a Balance between Artifact and Theory

With the rising interest in Design Science Research (DSR), it is crucial to engage in the ongoing debate on what constitutes an acceptable contribution for publishing DSR - the design artifact, the design theory, or both. In this editorial, we provide some constructive guidance across different positioning statements with actionable recommendations

for DSR authors and reviewers. We expect this editorial to serve as a foundational step towards clarifying misconceptions about DSR contributions and to pave the way for the acceptance of more DSR papers to top IS journals.

Richard Baskerville (Georgia State University), Aboyomi Bayere (Copehagen Business School, University of Turku), Shirley Gregor (Australian National University), Alan Hevner (University of South Florida), Matti Rossi (Aalto University): **Design Science Research Contributions: Finding a Balance between Artifact and Theory**

Journal of the Association for Information Systems; Atlanta Vol. 19, Iss. 5, (2018): 358-376.
https://doi.org/10.17705/1jais.00495

Networks, business models, and competitiveness in small Finnish firms

Small firms must design business models that leverage the resources of others to succeed in domestic and global markets. This study investigates the variance in business models of small firms seeking to prosper through networking within an intensely competitive landscape. We use explorative quantitative methods to analyse the link between networking, business models and financial performance of 90 small and industrial Finnish firms. The results reveal five types of business models: two of them are oriented internationally and three are oriented domestically. We mapped these business model types within a financial outcomes matrix to capture the differences in business model performance and found that competitiveness and financial performance of small firms under globalisation depend on their business model and networking strategy. In particular, inter-organisational networking contributes to sales growth and international expansion contributes to improved profitability.

Mika Westerlund (Carleton University), Diane A. Isabelle (Carleton University), Risto Rajala (Aalto University), Seppo Leminen (Laurea University of Applied Sciences): **Networks, business models, and competitiveness in small Finnish firms**

International Journal of Business and Globalisation, Vol. 18. (1), 9-26. 2017
https://doi.org/10.1504/IJBG.2017.081029

From the profit of one toward benefitting many – Crafting a vision of shared value creation.

In the world of interconnected business ecosystems, corporate social sustainability is not a single-firm endeavor. Instead of pure profit-making, companies should focus on shared value creation with the surrounding community. This study reveals that achieving shared value paradigm is complicated by actors' relationships with their institutional, organizational, and socio-material environments. To break the status quo and shake the institutional field, actors need to form a strong shared vision and put it into action. In our qualitative in-depth case study in the health care sector, we investigate how a single company formed and implemented a vision of social sustainability leading to the health care campus development project. Based on our empirical findings, we formulate a theoretical framework delineating shared value creation through three active phases within three realms: (1) shaping the vision by forging the

norms in the institutional realm, (2) sharing the vision through collaborative actions in the organizational realm, and (3) anchoring the vision by casting the foundations in the socio-material realm. The framework suggest that institutional change towards shared value creation requires a reformation of existing practices to meet new community based logic within the field. This requires radical actions and faces distinctive challenges in all three identified realms. The findings contribute to the growing body of literature linking the shared value creation with corporate social responsibility and institutional theory. We conclude by outlining managerial implications of the study and suggesting potential avenues for future research.

Juri Matinheikki (Aalto University), Risto Rajala (Aalto University), Antti Peltokorpi (Aalto University): **From the profit of one toward benefitting many – Crafting a vision of shared value creation.**

Journal of Cleaner Production, 162, 83-93
https://doi.org/10.1016/j.jclepro.2016.09.081

A Value Proposition Development Framework for Industrial Service

Value proposition is a key concept in the research on service and in the practice of service management. Value propositions are described as tools to communicate and motivate a joint value creation opportunity among involved organizations and stakeholders. The future orientation and intangibility of service places value proposition as the key element of competitive service business. However, the concept of value proposition if often vaguely defined, the underlying theoretical concepts missing, and the managerial practices to create value propositions unexplored. This study investigates how value-focused industrial companies build value propositions by conducting customer value research. Building on our findings, we suggest theoretical and managerial frameworks for value proposition development.

Pekka Töytäri (Aalto University), Risto Rajala (Aalto University), Lucas Nilsson-Ollandt (Aalto University), Joona Keränen (Lappeenranta University of Technology): **A Value Proposition Development Framework for Industrial Service**

Proceedings of the 50th Hawaii International Conference on System Sciences | 2017
http://hdl.handle.net/10125/41348

Overcoming Institutional and Capability Barriers to Smart Services

Smart services have potential to improve value creation and profitability of industrial firms and their customers. Defined as services that go beyond the upkeep and upgrades, traditionally bundled with products and helping companies to build intelligence— that is, awareness and connectivity. Combined with digitalization, services have had a major role in improving efficiency of existing offering and enabling new channels for service delivery. Implementing the change toward smart services is challenging. Research shows that especially industrial companies maintain institutionalized beliefs and attitudes impeding the transformation, lack capabilities and resources for implementation, and

face industrywide norms and relationship practices resisting the change. The study explores the barriers in adopting smart services and is implemented as a multi-case study among six globally operating industrial companies.Our findings indicate classification of internal barriers, capability gaps, and external barriers, contributing a framework that describes the interplay between institutional forces and capability development in organizational change.

Pekka Töytäri (Aalto University), Taija Turunen (Aalto University), Maximilian Klein (University of St. Gallen), Ville Eloranta (Aalto University), Sebastien Biehl (University of St. Gallen), Risto Rajala (Aalto University): **Overcoming Institutional and Capability Barriers to Smart Services**

Proceedings of the 50th Hawaii International Conference on System Sciences, 2017
http://hdl.handle.net/10125/41351

Prospects of CPQ: evolving toward industry platforms

Since CPQ (Configure, Price, Quote) suppliers are often referring to their products as platforms, a question arises as to what extent present CPQs have such characteristics supporting platform ecosystems. In this paper, the features of seven case CPQs are compared to each other and to the critical characteristics of a multisided platform. CPQs have diverse features, and most are very similar to their competitors. CPQs are internal platforms, but they typically do not have the characteristics of industry platforms that enable multisided ecosystems. Some CPQs are clearly on the way to becoming true multisided platform ecosystem enablers, but none of the case CPQs studied was ready yet.

Krista Sorri (Tampere University of Technology), Miika Kumpulainen (Tampere University of Technology), Marko Seppänen (Tampere University of Technology), Michael Dunne (Apttus), Kai Huittinen (Wapice Oy): **Prospects of CPQ: evolving toward industry platforms**

Proceedings of 9th International Workshop on Software Ecosystems, CEUR-WS.org, 2017
http://urn.fi/URN:NBN:fi:tty-201801261150

Platform design framework: conceptualisation and application, Technology Analysis & Strategic Management.

Technological platforms enable actors to connect their resources across markets, creating value through complementarities and network effects. The design choices related to different aspects of a platform are crucial for ensuring value creation. Building on earlier literature, we have developed a framework for platform design, involving four elements: 1) platform architecture, 2) value creation logic, 3) governance, and 4) platform competition. Using a design science approach, we provide an empirical illustration of design choices in the Mobility-as-a-Service (MaaS) platform DORA. The study presents an overarching framework for platform design, with an empirical use case illustrating its applicability.

Nina Tura, Antero Kutvonen & Paavo Ritala (Lappeenranta University of Technology) (2017): **Platform design framework: conceptualisation and application, Technology Analysis & Strategic Management**

Technology Analysis & Strategic Management, 2017
https://doi.org/10.1080/09537325.2017.1390220

Barriers to implementing value-based pricing in industrial markets: A micro-foundations perspective

Value-based pricing has the potential to improve differentiation, profitability, and value creation for industrial firms and their customers. However, while most of the pricing research considers the ways organizations set or get value-based prices, only few studies consider how individual managers influence the pricing process and what prevents them from setting and getting value-based prices. This is of critical concern, since it is not just organizations, but individuals within organizations who make pricing decisions—and their decision-making is influenced by institutional pressures such as socially prescribed norms, rationalized meanings, and beliefs about profitable approaches to pricing. This study addresses this gap in the current knowledge by adopting a micro-foundations perspective to pricing, and focusing on the barriers that individual managers encounter when implementing value-based pricing. Drawing on a single case study in a global industrial firm, and from interviews with 24 managers, this study identifies 11 individually, organizationally, and externally induced barriers to value-based pricing. The study also sheds light on the potential sensegiving strategies for overcoming these barriers.

Pekka Töytäri (Aalto University), Joona Keränen (Lappeenranta University of Technology), Risto Rajala (Aalto University): **Barriers to implementing value-based pricing in industrial markets: A micro-foundations perspective**

Journal of Business Research, 2017
http://dx.doi.org/10.1016/j.jbusres.2016.04.183

Usage Data Analytics for Human-Machine Interactions with Flexible Manufacturing Systems: Opportunities and Challenges

Analyzing data from complex production systems and processes can be used in improving existing products, processes, and services, and innovating novel offerings. We report the findings from a six-month case study with a company developing flexible manufacturing systems. During a collaborative development process of a data analytics and visualization tool, our goal was to identify potential metrics, business opportunities, and challenges when utilizing logged data of end-users' human machine interactions in development activities. Our key contributions include a characterization of the potential usage data metrics to be logged and visualized, identification of opportunities this data entails for business, and discussion about the challenges related to usage data logging in the studied context. Finally, we propose topics that should be consid-

ered in the organization before investing in usage data logging in the context of flexible manufacturing systems.

Jari Varsaluoma, Heli Väätäjä (Tampere University of Technology), Tomi Heimonen (University of Wisconsin-Stevens Point), Katariina Tiitinen, Jaakko Hakulinen, Markku Turunen (University of Tampere), Harri Nieminen (Fastems Ltd.): **Usage Data Analytics for Human-Machine Interactions with Flexible Manufacturing Systems: Opportunities and Challenges**

IEEE Xplore: 16 November 2017
https://doi.org/10.1109/iV.2017.38

Cognitive Mimetics for Designing Intelligent Technologies

Design mimetics is an important method of creation in technology design. Here, we review design mimetics as a plausible approach to address the problem of how to design generally intelligent technology. We argue that design mimetics can be conceptually divided into three levels based on the source of imitation. Biomimetics focuses on the structural similarities between systems in nature and technical solutions for solving design problems. In robotics, the sensory-motor systems of humans and animals are a source of design solutions. At the highest level, we introduce the concept of cognitive mimetics, in which the source for imitation is human information processing. We review and discuss some historical examples of cognitive mimetics, its potential uses, methods, levels, and current applications, and how to test its success. We conclude by a practical example showing how cognitive mimetics can be a highly valuable complimentary approach for pattern matching and machine learning based design of artificial intelligence (AI) for solving specific human-AI interaction design problems.

Tuomo Kujala, Pentti Saariluoma (University of Jyväskylä): **Cognitive Mimetics for Designing Intelligent Technologies**

Advances in Human-Computer Interaction, Volume 2018, Article ID 9215863,
https://doi.org/10.1155/2018/9215863

Virtual Environment for Training Autonomous Vehicles

Vehicles incrementally contain more features for the preparation of autonomous vehicles. These features are embedded for mainly two reasons: collecting data for the training of driving algorithms, and using these vehicles as testbeds for the algorithms. Due to the nature of algorithms used in autonomous vehicles, their behavior to Unknown situation is not fully predictable. This calls for extensive testing. In this paper, we propose the use of a virtual environment for both testing algorithms for autonomous vehicles and acquiring simulated data for their training. The benefit of this environment is to able to train algorithms with realistic simulated sensor data before their deployment in real life. To this end, the proposed virtual environment has the capacity to generate similar data than real sensors (e.g. cameras, LiDar, . ..).

After reviewing state-of-the-art techniques and datasets available for the automotive industry, we identify that dynamic data generated on-demand is needed to improve the current results in training autonomous vehicles. Our proposition describes the benefits a virtual environment brings in improving the development, quality and confidence in the algorithms.

Jerome Leudet, Tommi Mikkonen, Francois Christophe, Tomi Männistö (University of Helsinki): **Virtual Environment for Training Autonomous Vehicles**

TAROS'18 conference (Towards Autonomous Robotic Systems)
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Strategic Positioning in Big Data Utilization: Towards a Conceptual Framework

This paper introduces a conceptual framework for strategic big data utilization. We discuss big data through (i) its origins (where and how does the data accumulate), (ii) its constitution (what is the nature of the data), and (iii) its applications (how and why can the data be processed and utilized). Based on this conceptual analysis, we argue for three continua that can guide the process of making strategic decisions regarding the utilization of big data. We further use these continua as a foundation for proposing a conceptual framework for strategic data use and strategic positioning. The conceptual framework facilitates understanding the firm-specific possibilities that emerge from aligning the overarching business goals with the opportunities emerging from big data.

Milla Wirén, Matti Mäntymäki (University of Turku): **Strategic Positioning in Big Data Utilization: Towards a Conceptual Framework**

In: Al-Sharhan S. et al. (eds) Challenges and Opportunities in the Digital Era. I3E 2018. Lecture Notes in Computer Science, vol 11195. Springer, Cham
https://doi.org/10.1007/978-3-030-02131-3_12

Customer participation in knowledge intensive business services: Perceived value outcomes from a dyadic perspective

Knowledge intensive business services (KIBS) are considered a cornerstone of contemporary developed economies. Successful production and delivery of these services, and thus their perceived value outcomes, highly depend on customer participation (CP) in the service processes. However, the extant understanding of the perceived value outcomes of CP, which is crucial to the appropriate inducement and integration of organizational resources in service processes, is limited. Through the exploratory investigation of three dyadic cases, each comprising one customer and one service provider organization engaged in a knowledge-based service project, this study addressed this crucial topic. Results indicated four categories of perceived value outcomes emerged through CP: functional, economic, relational, and strategic values. The study provides insights on the evolution of value perceptions over time, the individual value components within each value category, and perceptual similarities and differences between customer

and provider organizations. Further, these results indicate that various value outcomes of CP receive divergent levels of attention from personnel in different organizational hierarchies. The paper provides useful and applicable suggestions for managers, especially in the context of technology-based KIBS and solutions.

Mustak, Mekhail (2018): **Customer participation in knowledge intensive business services: Perceived value outcomes from a dyadic perspective. Industrial Marketing Management**
https://doi.org/10.1016/j.indmarman.2017.09.017


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