Towards Smart Data-oriented Services
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Recent academic research has paid particular attention to how digitalization disrupts current business models and business environments. Furthermore, servitization has gained significant attention. Currently, industrial internet-based services have not yet been adequately integrated into clients’ business processes and the potential benefits of digitalization have not yet been fully exploited. A collaborative R&D project named SmartAdvantage has been initiated to meet this challenge, the first results of which are presented in this deliverable.

The goal of the SmartAdvantage research project is to enhance the opportunities for value creation for industrial ecosystems by developing novel approaches and business models for digitalized asset management. The project is seeking new knowledge about how companies can better exploit data and create customer value through smart asset management services in global markets.

This research is being carried out by VTT Technical Research Centre of Finland Ltd and Tampere University of Technology.

The development work is being carried out in close cooperation with companies in order to create opportunities to share experiences, benchmark and to learn from each other. In addition, the research institutes and industrial partners work together efficiently by combining their expertise.

The authors wish to thank SmartAdvantage’s industrial partners, Chiller Oy, Delete Oy, Huurre Oy, Pesmel Oy, SW-Development Oy, for their active role in the preparation and implementation of the project right from the outset. The project is funded by Tekes Research Benefit programme, VTT, TUT and the participating companies.

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AUTHORS
1. INTRODUCTION

There were two main objectives for the first 6-month period of the SmartAdvantage project: 1) to identify the opportunities and challenges of digitalization in asset management, and 2) to provide an understanding of how previous research results - methods, models and frameworks - may be utilised in industrial ecosystems.

This deliverable, which encompasses the findings of the first period, can be divided into four parts:

- The first part provides information on what the project partners understand by digitalization. It proposes the elements needed in the digitalized asset management, discusses the opportunities and presents a roadmap for related services at a generic level.
- The second part presents case studies of the SmartAdvantage business partners.
- The third part analyses the opportunities, barriers and enablers for digitalized asset management.
- The fourth part presents a framework for the development of smart data-driven services and discusses the potential for exploitation of existing methods, models and frameworks at different stages of the service development.

This report provides ideas about how to determine the range of opportunities offered by digitalization, how to make an effective start with data-based services and which tools may be useful at different stages during the implementation of these services. The work in the project is being carried out in close collaboration with the project partners, and the major part of the project work is taking place in the case studies presented in Section 3. The project has organized two workshops aimed at sharing experiences, practices and the latest results from both the research organisations and industrial partners. The results from the case studies and workshops, along with a tailored complementary literature review, have been utilised in writing the third and fourth parts of this deliverable.

Taken together, the overall aim of this deliverable is to share our experience and understanding of how to create new profitable businesses based on intelligent assets and data.
2. DIGITALIZED ASSET MANAGEMENT

What do we understand by digitalization?

Digitalization can be defined as the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business (Gartner 2016). A digital business can be defined as the creation of new business designs by blurring the digital and physical worlds (Gartner 2016).

Digitalization has already transformed many sectors of industry and society, such as media, banking and communications. However, in the future, it is expected to transform the industries and society even further (OECD 2015, World Economic Forum 2015).

Large Finnish technology companies had already started developing knowledge-based services long before any widespread discussion of the topic of digitalization or the industrial Internet had appeared. One key problem, though, is that the services being developed have usually been regarded as products, the use of which is the customer’s responsibility (Ahonen & Vossi 2016). Customer’s decision-making processes at different organizational levels have not been known, so the service providers have not been able to match their service offerings to the customer’s real needs. As a result, the use of data and digital channels in industrial services is, in many ways, very limited. This means that even the pioneer companies of digitalization still have significant room to improve their utilization of services in the key areas of asset management, performance optimization, maintenance and investment management. The need for information and knowledge exists at three levels, i.e. the strategic, tactical and operational levels. However, although each level has its own needs and demands, most of the current digital solutions are only targeted at the operational level.

The SmartAdvantage project is based on the need to take a comprehensive approach to digitalization, in which added value is created through the introduction of new business models and operational practices. This can be achieved through understanding the importance of the different types of information and requirements set by the complex company networks, and through identifying profitable ways to exploit new technologies (see Figure 1), all of which must support the organisation’s strategic objectives.

FIGURE 1. A FRAMEWORK FOR THE TRANSFORMATION TOWARDS DIGITAL BUSINESS (ADAPTED FROM PAASI, 2017).
How do we understand asset management in the context of digitalization?

ISO 55000 (2014) defines asset management as follows: “Asset management supports the realisation of value while balancing financial, environmental and social costs, risks, quality of service and performance related to assets”.

This definition takes into account the increasing complexity, uncertainty and requirements that asset managers have to face. Contemporary industrial networks often have a number of organizations as key stakeholders, including asset operators and owners, regulatory and statutory bodies, service providers, engineering contractors, technology developers, equipment manufacturers, spare part vendors and logistics providers (Liyanage 2012).

The effect of digitalization on asset management can be discussed in the light of the asset management fundamentals presented in ISO 55000 (2014):

- **Value.** The goal of asset management is to provide tangible or intangible value to the organisation. The value is determined by the organisation and its stakeholders so that it is aligned with the organisational objectives. Use of a lifecycle approach is emphasised.
- **Alignment.** Organisational objectives are translated into technical and financial plans and decisions by asset management. Organisations should have risk-based and information-driven planning and decision-making processes, integration of asset and functional management processes (e.g., finance, human resources, information systems, logistics and operations) and the specification and implementation of supporting asset management systems in place.
- **Leadership.** Leadership and workplace culture are elements determining the realization of value. Organisations should consider having clearly defined roles and responsibilities, ensuring that their employees are aware, competent, and empowered, and consulting with employees and stakeholders regarding asset management.
- **Assurance.** Asset management should give assurance that assets fulfil their required purpose. In order to fulfil the needs of assurance, organisations should implement processes for connecting the purposes and performance of the assets to the organizational objectives, for assurance of capability and for monitoring and continual improvement, and they should provide the necessary resources and competent personnel to demonstrate assurance.

The fundamentals can be divided into two categories; value itself, and any activities supporting value creation. These include alignment, leadership and assurance. This categorization is useful when analysing the effects of digitalization on asset management. For instance, digitalization enables better management of life cycle information and better availability of sensor, equipment and process information for the various stakeholders. Therefore, the potential new value could be in real-time optimisation and predictive maintenance. These opportunities may positively affect all the asset management fundamentals.

On the other hand, the lifetime of digitalized products and services is often much shorter than the physical assets. This can be seen as a challenge for such fundamentals of asset management as value and assurance, since companies have to prepare for new kinds of maintenance, replacements and modernisations.

In Section 4 of this publication, we present the opportunities, enablers and the barriers that the SmartAdvantage case companies have identified when considering digital asset management services.
What is the role of data and data analytics in digitalized asset management?

The recent development in wireless technologies and the growing interest in digitalization and its possibilities has rapidly increased the amount of available data in industrial applications. Furthermore, the information contained in such data offers huge potential for developing new tools for value creation through digitalized asset management. In particular, applications based on the Industrial Internet and IoT are becoming ever more popular in industry, which has created a huge demand for more efficient ways of utilizing the available data (Da Xu et al. 2014). However, the vast amount of available data has to be further mined and analysed in order to gain information that could be useful for the decision-making processes in asset management. Therefore, data analytics and data mining are invaluable tools for dealing with this vast and wide-ranging sea of data.

The possibilities offered by data analytics and data mining in IoT applications are numerous, and are expected to revolutionize the future of service offerings in an industrial environment (Tsai et al. 2014). The most common applications for the utilisation of the data available from industrial applications are related to condition-monitoring, machine prognostics and reliability issues. In addition, such applications provide vital tools for implementing more efficient proactive maintenance services, for example. However, there are many more opportunities for companies to improve their service offerings by utilising the constantly growing amount of available data more efficiently. Therefore, the opportunities that different data analytics and data mining methods can provide for the service business in a modern industrial environment need to be studied further.

The main aim of data collection and analysis in the area of asset management is to support various decision-making situations. The data, information, knowledge and wisdom (DIKW) hierarchy is a basic model describing the levels of understanding and functions as a path to make data useful for decision-making (e.g. Rowley 2006, Kankaanranta 2012). In practise, decision-making requires a combination of hard and soft data. Hard data is measured values, which in industry are typically collected by sensors, maintenance event reports, and so on. Soft data is, for example, a human understanding of the structure of a system, or expert judgements about values that cannot be physically quantified. Figure 2 depicts the relationship between DIKW hierarchy and the data analysis process. From the service business perspective companies need to recognize which level in the data to wisdom hierarchy their services will represent.

![FIGURE 2. RELATIONSHIP BETWEEN DIKW HIERARCHY AND DATA ANALYSIS PROCESS (KUNTTU ET AL. 2016)](image-url)
How can value be created for digitalized asset management and how can it be measured?

According to the ISO 55000 definition, asset management involves maintaining and securing the equipment and systems in, or restoring them to, a state in which they can perform the required functions. One challenge in planning asset management activities is to identify appropriate objects and tasks for preventive maintenance, and to ensure that there are adequate resources for any needed repairs. So, any organization offering digitalized asset management services must be able to show the added value of their solutions in terms of the strategic and tactical objectives of the prospective customer. These objectives can vary significantly according to the customer’s business environment, so service providers must be able to define the value of their solutions on a case-by-case basis.

Nevertheless, the value gained from digitalized asset management services is usually dependent on one or more of the following aspects:

• solutions enabling faster, more inexpensive and comprehensive data collection
• faster and real-time data analytic technologies
• better opportunities to combine data from different sources
• better availability of analysed data

More comprehensive data and enhanced analytic competences provide an opportunity to improve asset management services by doing appropriate activities faster, correctly, on right time and with right resources. In other words, digitalization can be regarded as an enabler for carrying out the right asset management tasks at the right time. The right asset management tasks are those which strongly support both the achievement of the service provider’s own KPIs, and those of the customers. These KPIs could include metrics such as overall equipment efficiency (OEE), life cycle cost/profit (LCC/LCP), availability, emission levels, and accident rates.

Depending on the particular case, the value of digitalized asset management services can be created through one or more of the above-mentioned aspects. The boundaries between these aspects can be blurred and overlapping. For example, performing maintenance actions correctly often results in faster repair.

Maintenance services are a typical example of digitalized asset management services. One example of a maintenance service is ‘SKF Rotation For Life’ provided by SKF, a worldwide manufacturer and supplier of ball and roller bearings, linear motion products, precision bearings, spindles and seals. The service combines bearing technology, failure detectability and reliability services into an integrated package. Digital solutions can provide the tools and methods needed to collect and analyze data in order to detect emerging failures at an early stage, and thus to react to them at the right time. Giving case-relevant repair instructions to field through e.g. mobile solutions can support doing things correctly.

Another example of digitalized services is offered by a company called TTS-Ciptec, which offers CIP (clean in place) wash optimization services for process washes to e.g. dairies and breweries. The optimization of the clean-in-place washes is conducted through remote monitoring of in-going and returning washing liquids and predictive analytics services related to these monitoring results (TTS-Ciptec homepages). In this case, digitalized solutions reduce CIP times, so the CIP wash can be conducted much faster than it would have been done without this service. CIP optimization also includes the perspective of resources savings, as when the washing time is reduced, so are the demands for water, energy and chemicals.
How to draw a roadmap for a digitalized asset management service business?

The Internet of Things, the Industrial Internet, big data, data-based services and digital services are all part of the modern trend in digitalization where companies are seeking more value, both in their own internal processes and in the products and services offered to their customers. Smart connected products provide new capabilities for monitoring, control, optimization and autonomy, as described by Porter & Heppelmann (2014). Over recent years, many authors (e.g. Evans & Annunziata 2012, Manyika et al 2013, Porter & Heppelmann 2014) have recognised the fundamental changes that digitalization brings with it. New types of products and services and new strategies can have an influence on how assets can be best managed, how performance can be optimised and how new business models can be created. It is generally acknowledged by researchers that the potential for value creation in terms of savings and added customer value is significant.

The impacts of the Industrial internet and digitalization are expected to be systemic in many industries. Therefore, understanding their effects and managing their development is far more difficult than it has been for purely technology-based concepts or for incremental changes in business models. Although the literature does include a number of examples of digitalization in asset management, there are relatively few examples of thorough transformations involving the efficient integration and exploitation of digital channels of data in industrial environments.

While many of the impacts of digitalization are difficult to predict beforehand due to their systemic nature, many companies have adopted productivity, lead times, features, quality and cost as the drivers behind the creation and development of digital concepts (Sommarberg 2016). Naturally, companies are in different positions and at different levels of preparedness with respect to digitalization. Some companies have had earlier unsuccessful experiences with pilot digitalization projects. Others are just now taking the first steps towards digitalization by, for instance, installing monitoring capabilities for the warranty period of their product. Finally, a few companies can be regarded as pioneers in the field, with offerings of e.g. remote asset and fleet optimisation.

Figure 4 presents a generic roadmap for industrial companies that wish to move towards a more comprehensive digital asset management service portfolio. This roadmap calls for changes in business models, product and service development, and service processes, which need to be understood as a whole (Ahonen et al. 2015). The role of the provider, and the digital service, is dependent not only on its own capabilities, but also on the general business environment and the customer’s particular operational environment. Currently, the situation in larger, more complex production sites may involve a large number of providers who are all keen to take on the integrator role with their own platforms for data management. Early IoT trials with many service providers have resulted in a scattered and uncoordinated range of solutions. Companies with the ability to understand the requirements of such complex industrial environments, and to create a roadmap for a service portfolio meeting these challenges, have an opportunity to gain a clear competitive advantage.

**FIGURE 4. A GENERIC ROADMAP FOR DIGITALIZED ASSET MANAGEMENT SERVICES.**
3. DEVELOPMENT DRIVERS AND NEEDS OF THE SMARTADVANTAGE PARTNERS

3.1 CHILLER OY

Chiller is one of Europe’s leading manufacturers of energy-efficient and optimized air-conditioning solutions. Based on a high level of expertise, Chiller designs and implements solutions for high-demand projects.

Chiller’s vision is to produce novel customer value and optimise the use of assets throughout their life cycles, as well as to increase the internal efficiency and enable new business models to be implemented. Chiller wishes to challenge current practices and promote changes in technologies, operational models and service processes.

Chiller’s ultimate objective is to create novel business opportunities through the exploitation of wireless communication technologies and big data analytics. Thus, Industrial Internet technologies will be exploited to optimise the whole lifecycle of their products. In addition to their current remote monitoring and their use of planning and maintenance tools, Chiller aims to promote data transfer and analytics throughout the different sections of an organisation. The technology and business models are developed concurrently to enable the efficient utilisation of the increasing amounts of available data.

While there is a good deal of information currently widespread, the Industrial internet is expected to make all the relevant data and information available for the ones to exploit it, in all the phases of the service processes. Chiller thus aims to offer intelligent air conditioning solutions, enabled by new technologies and delivered with new business models.

3.2 DELETE OY

Delete is an environmental full-service company operating in the Nordic countries. It provides cleaning, demolition, recycling and waste-processing solutions for different applications. As a one-stop-shop, Delete can provide entire service chains, with an extensive range of equipment, and competent experts to support the customer’s business operations.

Delete is keen to adopt digitalization as a key part of its strategy, and is looking for new business models based on digital services. Delete is striving to learn how digitalization may increase efficiency in its own processes, and also how it can create added value for its customers. Thus, organisational understanding needs to be increased of how Delete’s service portfolios may be digitalized, and how their new digitalized
3.3 HUURRE OY

Huurre Oy is an international refrigeration services company, with a vision of becoming a global leader in selected markets by improving the efficiency and safety of global cold chains.

Based on the experience already gained from its current IoT offering, Huurre recognises the huge potential of improved digital services. Huurre aims to create the capabilities determined by performance-based business models, and to study the changes arising from the introduction of potentially disruptive new business models. One interesting service concept for Huurre, based on a performance-based business model, is to provide refrigeration as a service (RAAS).

Huurre began its digitalization-related development work over ten years ago, when it started to develop a digital platform currently known as iTOP. The company already has considerable experience of providing services for remote control and is aware of the opportunities offered by the latest digitalization technologies.

Huurre’s primary aim is to thoroughly understand the requirements and effects of new business models from both the service provider’s and the customer’s perspectives. They want to identify what types of business models may be profitable, which technologies would best fit the new business models and what are the appropriate key performance indicators for assessing the developed business models.

The creation of new customer value is regarded as the driving force for all development activities. This calls for research and development that integrates the customers in the process. Customer needs and other drivers for new business models are identified, new business models are explored and the opportunities for the utilisation of data analytics are explored from the very first phase of a project. The actual creation of the capabilities needed for these value-adding business models and technologies will take place during the second phase.

For Huurre, digitalization provides new opportunities to develop their service business, to break into new markets, and to increase profitability. Along with the adoption of new business models, all of this is expected to create considerable value to their customers.
Pesmel is a global supplier of highly automated internal logistics, storage and packaging systems for the metal, paper and converting industries.

Pesmel is searching for new opportunities for digital services in order to develop a more comprehensive Enterprise Asset Management service portfolio. This means that while existing service models are being digitalized, in the long term Pesmel is searching for new opportunities to increase customer value through digitalization. At this point in time, Pesmel is concentrating on the development of its FlowCare service platform, which already includes acquisition and visualization of all the available information. Their goal is to create a platform that enables a more comprehensive and long-term relationship with the customers throughout the product lifecycle, and to provide services for improving the system’s reliability.

The customers’ response to this digitalized visualization and analysis of the data acquired from the system has been extremely positive. Therefore, Pesmel is also looking for the possibility to implement Enterprise Asset Management tools, more throughout data acquisition solutions and data analysis features in the FlowCare platform. These features would enhance Pesmel’s data management in a variety of ways. These include system deliveries, creating a basis for predicting a system’s condition and the need for maintenance operations, optimizing the system’s performance and, above all, creating new value for the customers by expanding Pesmel’s service portfolio.

Pesmel’s vision for the FlowCare platform is to provide services which enable improvements in the dependability of customer’s systems. The service will help the customers to anticipate exceptional circumstances and rare events. It also offers a way to rationalize maintenance planning and maintenance actions, and enables maintenance need prediction. The digital service platform works both as a customer service platform and as a marketing channel. Pesmel’s vision is also to create offerings for global markets with the ability of selling capacity in addition to traditional product sales. The idea is that the FlowCare platform will provide customer support throughout the whole lifecycle of the product/project via the installation of a chat feature, an online store and the possibility to share information and documents with customers on the FlowCare platform. It should be possible for Pesmel to execute relevant communication with its customer through the platform.

SW-Development operates in Finland and Sweden and specialises in improving the profitability of supply chains. The company focuses on improving their customers’ production and logistics processes by utilizing intelligent simulation and optimization systems. These increase the accuracy of the strategic, tactical and operational planning, thus enabling more efficient utilisation of resources to achieve a competitive advantage.

Recent developments have forced companies to broaden their product portfolios and to reduce their batch sizes. This has set new challenges, as companies now have to constantly re-design and optimize their production operations. SWD is interested in solving these challenges by developing new service solutions which will optimize production operations so that they can react to changes in operational demands in real time. SWD is now focused on the development their latest offering, which is scalable and can be more easily implemented into the customer’s operations than is possible with the current project-based approach.

The development of new service solutions and products requires research into new ways of improving manufacturers’ production efficiency by optimising knowledge-based production planning. SWD is striving to identify new elements which can be developed and integrated into its current PES product portfolio. This research will be carried out as a project, whose aim is to support SWD’s international growth and provide more insight into the changes and future requirements expected in industry. SWD expects the project to furnish more information about how new technologies, and the increasing amount of data will influence future working practices.
4. OPPORTUNITIES, ENABLERS AND BARRIERS FOR DIGITALIZED ASSET MANAGEMENT

4.1 RECENT RESEARCH

Tables 1, 2 and 3 describe the opportunities, barriers and enablers for digital transformation identified from the most recent research and managerial publications. The results of the literature review are arranged according to the framework presented in Figure 1, which highlights the information, business, technology, strategy and management perspectives on the transformation towards a digitalized business.

The opportunities offered by digitalization have been discussed extensively in recent research publications (e.g. World Economic Forum 2015, Tihinen et al. 2016, Popescu 2015, Yoo et al. 2012). Table 1 presents the identified opportunities for digitalization.

There is also much discussion in the literature of both the barriers and the opportunities for digital transformation (Kane et al. 2015, Sommarberg 2016, Tihinen et al. 2016). Table 2 introduces some of the barriers for digitalization opportunities.

<table>
<thead>
<tr>
<th>Group</th>
<th>Service Operation</th>
</tr>
</thead>
</table>
| **Information**           | • Improved security  
                           | • Digital tools or digital components allow firms to build a platform of digital capabilities to be  
                           |   used throughout the organization to support its different functions (large complex information  
                           |   systems such as enterprise resource planning systems are increasingly serving as a platform  
                           |   to which other tools can be added in order to take advantage of shared data resources)  
                           | • Sharing data and processes across organizational boundaries  
                           | • Heterogeneity of knowledge resources increases with pervasive digital  
                           |   technology, and the quantity of knowledge that requires integration also continues to grow as  
                           |   new opportunities for convergent tools and products are generated |
| **Business**              | • Performance-based business models, instead of selling products or services. This requires a  
                           |   deep understanding of customers’ needs and business contexts.  
                           | • Improved operational efficiency through condition-based maintenance and remote  
                           |   management.  
                           | • Collaboration between humans and machines, which will lead to previously unseen levels of  
                           |   productivity in addition to more enjoyable work experiences.  
                           | • Higher customer satisfaction  
                           | • Cost savings  
                           | • Improved quality of service  
                           | • Distributed innovation |
| **Technology**            | • New connected ecosystems that can be merged on software platforms, blurring the traditional  
                           |   industrial boundaries |
| **Strategy and management**| • Better planning and control  
                           | • Increased vertical integration allows greater flexibility in both manufacturing and reducing the  
                           |   time-to-market  
                           | • Better integration of the horizontal value chains leads to better efficiency  
                           | • Being able to respond to sustainability requirements  
                           | • Improved security  
                           | • Faster decision-making |
The Enablers for digital transformation based on World Economic Forum (2015) and Sommarberg (2016) are listed in Table 3.

Based on an empirical analysis, Sommarberg (2016) argues that the most important economic and strategic drivers are: networks, crowds and platforms, convergence, radical innovation, and digital business models. Big data, AI and IoT are regarded as the most important technological drivers. In the same study, the most crucial barriers for digitalization are identified as: lack of competences and understanding, data security, quality, availability and ownership, management and industry beliefs, and technical barriers. Additionally, the most important enablers are identified as: the productivity leap, new insight, new business models, and platforms and networks.

Digitalization has the potential to have a major effect on the formation of strategy in companies. Due to the effects of pervasive digitalization, Sommarberg (2016) argues, companies should consider three factors in their strategy formation: (1) current management beliefs should be expanded to encompass the potential of digital disruption, (2) strategy formation by learning due to systemic and complex changes in business environment, and (3) the digital business model challenges companies’ current capabilities in traditional industries.

### TABLE 2. BARRIERS FOR DIGITALIZATION OPPORTUNITIES.

<table>
<thead>
<tr>
<th>Group</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>• Lack of relevant history data</td>
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<td></td>
<td>• Data security</td>
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<tr>
<td></td>
<td>• Data ownership confusion and conflict of interest</td>
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<td></td>
<td>• Management beliefs</td>
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<tr>
<td></td>
<td>• Lack of competences</td>
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<td></td>
<td>• Privacy concerns</td>
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<tr>
<td></td>
<td>• Lack of systemic understanding</td>
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<tr>
<td></td>
<td>• Cost and availability of data transmission</td>
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<tr>
<td></td>
<td>• Non sensor-installed fleet</td>
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<tr>
<td></td>
<td>• Lack of data governance rules</td>
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<tr>
<td>Business</td>
<td>• No strong business case</td>
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<tr>
<td></td>
<td>• Investment in current infrastructure</td>
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<td></td>
<td>• Industry-specific financial KPI’s</td>
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<td></td>
<td>• Industry beliefs</td>
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<tr>
<td></td>
<td>• Legacy competences, processes and systems and equipment</td>
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<td></td>
<td>• Return on continuous improvement</td>
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<td></td>
<td>• Data security risks and ownership</td>
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<td></td>
<td>• Incumbents’ active resistance</td>
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<td></td>
<td>• Lack of trust in virtual environments</td>
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<td></td>
<td>• High barrier industry</td>
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<td></td>
<td>• Rivalry between existing competitors</td>
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<td></td>
<td>• Cost-driven customers</td>
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<td></td>
<td>• High entry barrier industry</td>
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<td></td>
<td>• Long established stakeholder organizations</td>
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<td></td>
<td>• Oligopolistic market</td>
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<td></td>
<td>• Heightened complexity of the innovation process</td>
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<tr>
<td>Technology</td>
<td>• Insufficient technical skills</td>
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<td></td>
<td>• Lack of interoperability of existing systems</td>
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<td></td>
<td>• Uncertain risks arising from investment in new technologies</td>
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<td></td>
<td>• Immature or untested technologies</td>
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<tr>
<td></td>
<td>• Barriers in 3D printing (Limited size of object, slow speed)</td>
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<td></td>
<td>• Barriers in Cloud computing (Data security, legacy systems investments, lack of competences)</td>
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<td></td>
<td>• Barriers in Robotization (Legislation lagging behind, high capital cost)</td>
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<tr>
<td></td>
<td>• Internet of things (Lack of systemic understanding, cost and availability of data transmission, non sensor-installed fleet, data security)</td>
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<tr>
<td>Strategy and management</td>
<td>• Too many competing priorities</td>
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<td></td>
<td>• Lack of an overall strategy</td>
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<td></td>
<td>• Security concerns and data privacy</td>
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<td></td>
<td>• Lack of organizational agility</td>
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<td></td>
<td>• Lack of entrepreneurial spirit, unwillingness to take risks</td>
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<td></td>
<td>• Lack of collaborative, sharing culture</td>
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<td></td>
<td>• Lack of employee incentives</td>
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<td></td>
<td>• Cultural barriers</td>
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<tr>
<td></td>
<td>• Legacy leadership and management (leadership from the past)</td>
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<tr>
<td></td>
<td>• Risk-adverse business culture</td>
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<td></td>
<td>• Lack of absorptive capacity</td>
</tr>
<tr>
<td></td>
<td>• Next quarterly figures pressure</td>
</tr>
<tr>
<td></td>
<td>• Well established dominant logic</td>
</tr>
<tr>
<td></td>
<td>• Complex organisations</td>
</tr>
<tr>
<td></td>
<td>• Incrementalism</td>
</tr>
<tr>
<td></td>
<td>• Hierarchical organisations</td>
</tr>
<tr>
<td></td>
<td>• Impatience</td>
</tr>
<tr>
<td></td>
<td>• Inexperienced management</td>
</tr>
<tr>
<td></td>
<td>• Missing financial track record</td>
</tr>
</tbody>
</table>
### TABLE 3. ENABLERS OF DIGITAL TRANSFORMATION.

<table>
<thead>
<tr>
<th>Group</th>
<th>Enablers</th>
</tr>
</thead>
</table>
| Information            | • Reducing human errors  
• Scalability of knowledge  
• Analysis speed  
• Advances in cognitive computing  
• Users opening up their data  
• Platform tools                                                                                                           |
| Business               | • Digital entrants to traditional industries  
• Substitutive business models  
• Value-driven customers  
• Value-driven suppliers  
• Influential early adopters  
• Suppliers by-passing middle-men  
• Platform supply  
• Business model diffusion  
• Consumer business behaviour in B2B  
• Software intensity  
• Access to crowd knowledge  
• Influential Early Adopters  
• New level of customer insight  
• Powerful development tools                                                                                                   |
| Technology             | • General digital technologies  
• Enablers in 3D printing (Digital distribution, manufacturing recipe as IPR, sustainability, new product features, manufacturing close to point of use)  
• Enablers in Cloud computing (Enables new business models, Increased operational productivity, low cost computing, high supply of partners)  
• Enablers in Robotization (Systemic productivity, safety, good LCC predictability)  
• Enablers in Internet of things (Systemic productivity, customer insight, digital entrants to equipment business)                                                                                             |
| Strategy and management| • Management consulting focus  
• Management rotation  
• Emerging digital strategy frameworks  
• Experiment culture                                                                                                                                                             |
4.2 OPPORTUNITIES, BARRIERS AND ENABLERS RECOGNISED BY THE SMARTADVANTAGE CONSORTIUM

The SmartAdvantage companies and researchers have themselves identified the barriers, enablers and opportunities of digitalization in a workshop setting, utilising the World café method. We organised two groups consisting of a total of 6 researchers from VTT and TUT, and 8 company representatives from five companies. These groups discussed digitalization from three perspectives: (1) general opportunities, barriers and enablers at the society, industry and company levels, (2) opportunities, barriers and enablers of data management, and (3) opportunities, barriers and enablers related to business models and services. The discussions were facilitated by the researchers, who gathered the resulting ideas. The ideas generated by one group were discussed and enriched by the other group in an iterative process. At the end of the world café, the facilitators presented the ideas from the different thematic areas and the workshop participants commented on and further enriched them.

The opportunities of digital transformation identified by the workshop groups are presented in Table 4, the barriers in Table 5 and the enablers in Table 6. These opportunities, barriers and enablers will be further analysed in future SmartAdvantage publications by comparing the results of the literature review with the results from the workshops. The aim of the analysis is to create new hypotheses that will guide future research in the project.

<table>
<thead>
<tr>
<th>Group</th>
<th>Opportunities</th>
</tr>
</thead>
</table>
| Information | • With the support from remote connections, a best expert for any need or problem is always available for the customers  
• Decisions and actions can be taken based on analysed information, for instance, to minimise the down-time, measure the turnaround times, identify the bottlenecks and optimise the processes  
• Remote control of the processes, however, risks related to security and safety are to be considered  
• Information on how the assets are used  
• Information on the environment in which the assets are operating in order to optimise their use for that particular operating environment  
• Acquired data to third parties as a by-product  
• Huge amount of available data already exists. Companies are collecting “all data” from their machines (Process data, measurement data, environmental data). Currently, availability of the data and the technical implementation of data acquisition is not considered to be a problem. The main problem is that although a great amount of data is acquired, only a small part of it is utilized |
| Business | • Digital channels open up new opportunities for internationalization  
• Digitalization enables new partnerships. It is important to involve the customer in the co-creation of solutions, starting from the earliest development phase.  
• Changes in earning logic and operating model  
• Digitalization has the potential to change internal relationships and bring new actors to the ecosystem (machinery manufacturers to chassis manufacturers, or vice versa) |
| Technology | • Tailoring products and services for customer needs may lead to constant development and change to the business model, thus making it harder for the competitors to copy the product or service  
• Technologies that meet the requirements defined at the business level will produce the best results. There is a variety of equipment and technology platforms which are suitable for different applications. The ability to make the right choices in technology and digital platforms is a distinct competitive advantage |
| Strategy and management | |
### TABLE 5. BARRIERS OF DIGITAL TRANSFORMATION IDENTIFIED BY SMARTADVANTAGE GROUP.

<table>
<thead>
<tr>
<th>Group</th>
<th>Barriers</th>
</tr>
</thead>
</table>
| **Information**              | • Lack of relevant data and information for specific decision-making situations  
• Access to customer’s system is not always easy (depends on remote connections)  
• Integration between machines from different manufacturers is often deficient. Data is only acquired from each company’s own system, while there is currently no way of integrating the different databases. The sales and development of a company’s own product is considered as the main priority, which can cause delays in the acquisition of data. Is it possible for multiple companies to benefit from the acquired data? Who owns the data? Would it be possible to sell the acquired data?  
• The data analysis is often very straightforward and utilises only a small portion of the available data. There is neither the system or the knowhow to manage and utilise the huge amount of available data. Deep understanding of the process and the data analysis methods is distributed among the different companies. How can the available information be utilised as a whole? There are companies that are specialized in specific areas and that have the required specialist knowledge, but it is hard find the right actor for the purpose. More knowledge about what to do with the available data is needed  
• In some specific cases, environmental features and insufficient sensor technology might raise challenges for data acquisition  
• In some specific cases, environmental features and insufficient sensor technology might raise challenges for data acquisition  
• Value selling is different from what the providers have been doing in the past and is regarded as challenging  
• The customers’ focus is still too much on the acquisition price, instead of the total cost of ownership as opposed to the value throughout the asset lifecycle. In general, the customers may not be familiar with the services. The value creation may not be easily understandable so potential customers are unwilling to pay for new services. It may be that the customers are not ready for the change, in general. The procurement organisations may also not be ready for new collaboration and partnership models.  
• Earning logic: which models provide the most profitable outcome? Attention should be paid to pricing right from the beginning: if service is given free of charge to customers, customers might not even see the value in it in the long term either.  
• Digitalization is a major trend and there are a lot of different actors, products and services that are available. However, it is difficult to identify the true opportunities for the specific company and it calls for extensive knowledge of the market and experience.  
• The development efforts of a lot of companies have been technology-driven, with a lot of new technologies, measurements and analytics pilots. However, the business perspective - which might be considered as the primary aspect - has been put too far aside in many cases.  
• Companies may be afraid of cannibalizing their own current business and portfolio with the new digital services. However, there is a greater risk in doing nothing and letting the competitors take a leading role in the market. Thus, there is a risk of losing market share if a business fails to adopt new digital technologies and business models.  
• Internal opposition to change (may be even more meaningful than the customer opposition to change). This is often the result of inadequate discussion of the risks of change and ways to manage those risks. This can be countered by communicating better examples of the benefits and opportunities offered by the change.  
• Transition to new kinds of digital products and services requires new skills. For certain worker groups (often experienced personnel, but less technologically oriented) there may be an underlying fear of them losing their jobs. In many industries, the services and products have remained much the same for a long time. However, because of digitalization the speed of change is radical, not incremental and many employees may not have time to learn the new competences and technologies incrementally. Employees are currently expected to have multiple skills, combining mechanics, automation and ICT-related expertise. Lack of training and understanding of the changes incurred by digitalization at a management level is a risk.  
• Customers do not recognise the whole offering when they see the company only as a machine supplier. Customers’ viewpoint for the capabilities and potential of the firm is therefore limited, so they tend to search for solutions from established partners.  
• When using external machine-learning systems, there is a risk of losing own competencies.  
• Marketing digital services is an underdeveloped area. Marketing should be paid attention to more, both internally and externally. There is a need for clear messages and stories that people can identify with.  
• New, diverse know-how is needed for the new digital services, but the current employees may not necessarily have it (service personnel in general do not have all the necessary IT, automation and other specific competences)  
• Equipment and technology platforms: making right technology and platform choices which answer the customer’s needs  
• Tailoring products and services to the customer needs may lead to maintenance problems, and involves the management of many different versions  
• Lack of change leaders in companies |
In general, the groups identified a wide variety of business opportunities related to data, information, knowledge and wisdom based services, business model and market potential, the blurring of industrial borders, R&D and supporting technologies and competencies.

The main barriers identified are related to the perceived value, the business perspective and the customer needs, opposition to change, identifying the right supporting technologies and competencies, challenges in extending service delivery, the risk of losing one’s core competencies, access to all the information required for services, marketing and communication and R&D.

The group identified enablers related to partnerships, R&D (agile testing), marketing and communication, supporting technologies and competencies, references, business perspectives and customer needs.

In summary, to meet the challenges and opportunities of digitalization, companies need trust-based partnerships, agile development practices, internal and external marketing, and the establishment of new competences through, for instance, well-organized training of sales and R&D personnel. Data availability is usually not a problem in itself. However, although large amounts of data are currently being collected, often only a fraction of that data is utilized. This means that more know-how and competencies in the field of data analytics are needed.

### TABLE 6. ENABLERS OF DIGITAL TRANSFORMATION IDENTIFIED BY THE SMARTADVANTAGE GROUP.

<table>
<thead>
<tr>
<th>Group</th>
<th>Enablers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>• Partnerships in the development of services, products and competencies. The pilots and development projects should be at sites where fluent communication is guaranteed and the needs can therefore be understood well. A combination of short and long term objectives for the development guarantees both an adequate level of ambition for the whole digital transformation but also practical results which will satisfy the individual business cases</td>
</tr>
<tr>
<td></td>
<td>• Marketing new digital services to existing customers</td>
</tr>
<tr>
<td></td>
<td>• The pioneers act as encouraging examples. When a larger company takes the first steps towards digital services first, it makes it easier for the smaller players to follow suit</td>
</tr>
<tr>
<td></td>
<td>• Emphasising the business perspective and correctly identifying the customer’s needs in the development of digital services</td>
</tr>
<tr>
<td>Business</td>
<td>• Agile testing to complement long-term development, i.e. developing the product or service in small steps to understand the needs of the customers and produce short-term results quickly. The particular needs of individual customers are dealt with at a later stage, once the basic functionalities have been created</td>
</tr>
<tr>
<td></td>
<td>• Education and training is required throughout the whole organisation. For instance, the IT technology and the required competencies to exploit it must be communicated to all the service, sales and R&amp;D personnel.</td>
</tr>
<tr>
<td></td>
<td>• Cloud based solutions</td>
</tr>
<tr>
<td></td>
<td>• Companies should offer frameworks/platforms on which digital services can be easily used</td>
</tr>
<tr>
<td>Technology</td>
<td>• Transparency and commitment</td>
</tr>
<tr>
<td></td>
<td>• Internal information-sharing and marketing, creating a clear message and narrative</td>
</tr>
<tr>
<td>Strategy and management</td>
<td>• Transparency and commitment</td>
</tr>
<tr>
<td></td>
<td>• Internal information-sharing and marketing, creating a clear message and narrative</td>
</tr>
</tbody>
</table>
5. EXPLOITATION OF AVAILABLE METHODS AND TOOLS IN A DIGITALIZED ASSET MANAGEMENT SERVICE OFFERING

In addition to the standard approaches, the methods and approaches addressed in the SmartAdvantage project have been developed and utilized in a number of previous research projects. These methods are described in terms of the model for service information (McFarlane and Cuthbert 2012). Therefore, the SmartAdvantage approaches are presented according to the key stages of the service process (design, delivery, evaluation) and the definition of service (need, specification, offering and operation).

FIGURE 5. BOX MODEL FOR SERVICE INFORMATION REQUIREMENTS (MACFARLANE & CUTHBERT, 2012).

<table>
<thead>
<tr>
<th>Design</th>
<th>Service Operation</th>
<th>Service Offering</th>
<th>Service Specification</th>
<th>Service Need</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technical information to plan and develop the delivery of the offering</td>
<td>Technical / architectural / legal information to design offering</td>
<td>Information to formalize service contract</td>
<td>Conceptual information about customer requirement</td>
</tr>
<tr>
<td>Delivery</td>
<td>Technical information to run service / infrastructure</td>
<td>System level functional information to fully supply service offering</td>
<td>Information with respect to service use</td>
<td>Information from provider enabling user to exploit service</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Operational information on performance of service, infrastructure and operations</td>
<td>Information relating to the effectiveness of service offering and its SLA metrics</td>
<td>Information to illustrate the perception / expectation of the service – vs SLA</td>
<td>Information to determine fulfillement of customer need</td>
</tr>
</tbody>
</table>
Table 7 lists the methods and approaches presented according to the elements of the definition of service.

<table>
<thead>
<tr>
<th>Service definition/Method</th>
<th>Objectives and potential for the application of the method in a company’s service development processes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data analytics</strong></td>
<td>Service offering: Efficient utilization of the available data that enables the development of knowledge-intensive services for asset management. (Kunttu et al. 2016)</td>
</tr>
</tbody>
</table>
| **Interviews** (e.g. surveys, semi-structured interviews) | Service need: Support for identifying customer needs. Interviewing potential customers of the service help to identify the customer needs. 
Service specification: Interviews of the service providers and customers in order to:  
• Define the service concept  
• Find out how the service meets customer needs  
• Collect feedback from the customers on the concept of the services 
Service offering: Collecting feedback from customers 
Service operation: Collecting feedback from customers of performance of the service offering. |
| **Maintenance program planning methods** (RCM; IEC 60300-3-11 2009, VDMP; Rosqvist et al. 2009) | Service need: Support for transformation of customer strategic objectives into the objectives of the service. 
Service specification: Support for selecting viable target objects, correct components, for digitalized, preventive asset management services. 
Service offering: Support for selecting viable target objects, correct components for digitalized, preventive asset management services. 
Service operation: Support to update the list of selected viable target objects, correct components, for digitalized, preventive asset management services. |
| **Knowledge-based data analytics** (phenomena understanding) | Service need: Support for transformation of customer strategic objectives into the objectives of the service. 
Service specification: Support for selecting viable target objects, correct components, for digitalized, preventive asset management services. 
Service offering: Support for selecting viable target objects, correct components for digitalized, preventive asset management services. 
Service operation: Support to update the list of selected viable target objects, correct components, for digitalized, preventive asset management services. |
| **D2BK model** (Kunttu et al. 2016 & 2017) | Service need: Support to understand customers’ decision-making situations to recognize customers need for data-based services. 
Service specification: Support to recognize currently feasible data service level or to set target for future. |
<p>| <strong>Roadmapping</strong> (VTT Backpocket roadmap) | Service need: Roadmapping supports the synchronization of technology development and product or service planning. The method can be applied to exploring business opportunities. (Phaal et al 2004) Roadmaps can be utilized as visual narratives that describe the most critical elements and paths of the future development of the selected topic (Ahlqvist et al. 2010) |</p>
<table>
<thead>
<tr>
<th>Service definition/Method</th>
<th>Objectives and potential for the application of the method in a company’s service development processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criticality and root cause analysis</td>
<td>Service need: Support for selecting viable target objects, correct components for digitalized, preventive asset management services (Valkokari &amp; Rouhiainen 2000).</td>
</tr>
<tr>
<td>SQFD (Quality Function Deployment for services)</td>
<td>Service specification: Application of the method yields an analysis of how the elements of the service portfolio fulfil the existing customer needs. The very detailed documentation of how specific features of the services reflect the needs of the customers and which stakeholders are influenced by the services is emphasised. The analysis should result in a) a list of factors affected in the customer’s value creation processes, b) information on how the service influences these processes and c) a better understanding of the value elements based on which the service is successfully provided (Ahonen et al. 2010). Service offering: By analyzing how particular features of the services meet the customer needs, the value elements of the services and its value creation mechanisms are outlined and a basis is created for the quantification of service value (Ahonen et al. 2010).</td>
</tr>
<tr>
<td>Service blueprinting (Shostack 1984)</td>
<td>Service specification: Modelling the service process to visualize the content of services. Service operation: Modelling the service process to visualize the content of services and facilitating the testing of services.</td>
</tr>
<tr>
<td>Value mapping</td>
<td>Service specification: Assists in understanding and mapping various forms of value (positive and negative aspects of the business and its value network) and identifying conflicts between stakeholder interests, while analyzing value exchanges from a multi-stakeholder perspective to create positive value creation for the network. It assists in stimulating innovation, generating ideas and creating new sustainable value propositions. (Rana et al. 2017).</td>
</tr>
<tr>
<td>Life Cycle Cost/Profit LCC/LCP), (Woodward 1997, IEC 60300-3-3 2017)</td>
<td>Service specification: Support to define service price based on own costs of service delivery and value provided to customer Service offering: Support to demonstrate service value for customer’s business.</td>
</tr>
<tr>
<td>Value proposition canvas</td>
<td>Service need and offering: Defining the value proposition of the service. Specifying in detail the customer needs and clarifying how service(s) meet the needs. Designing the value proposition (Osterwalder et al. 2014).</td>
</tr>
<tr>
<td>Business model navigator</td>
<td>Service offering: Support for selecting the business model. The book presents 55 different business models and describes an approach for business model innovation (Gassmann et al. 2015).</td>
</tr>
<tr>
<td>(IoT) Business model canvas (Hakanen et al. 2017 Osterwalder &amp; Pigneur 2010)</td>
<td>Service need and offering: Support for creating a business model capable of supporting the digital transformation.</td>
</tr>
</tbody>
</table>
In the following table the methods intended to be used during the SmartAdvantage project are positioned to the model of service information requirements, presented by McFarlane and Cuthbert.

The SmartAdvantage project builds on a number of previous research projects and the work and methods discussed in this deliverable have their basis in the following projects:
- FleetAM (Tekes funded research project) - Fleet Asset Management (2007-2010). Further information can be found: http://virtual.vtt.fi/virtual/proj/FleetAM.
- StraSus (Tekes funded research project) - Strategic business models and governance for sustainable solutions (2013-2016). Further information can be found: http://www.vtt.fi/sites/strasus/en.
- SmartAdvantage collaborates with other on-going research projects, such as the Digital Disruption of Industry project (Finnish Academy), the Service Solutions for Fleet Management (FIMECC/S4Fleet) program and circular economy related Data to Wisdom project (http://www.vtt.fi/sites/datatowisdom/).

<table>
<thead>
<tr>
<th>Service need</th>
<th>Service Operation</th>
<th>Service Offering</th>
<th>Service Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td>Service blueprinting</td>
<td>Interviews</td>
<td>Knowledge-based data analytics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data analytics</td>
<td>Service blueprinting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maintenance</td>
<td>Maintenance program planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>program planning</td>
<td>SQFD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LCC</td>
<td>LCC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Value proposition canvas</td>
<td>Value proposition canvas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Business model navigator</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(IoT) Business model canvas</td>
<td>(IoT) Business model canvas</td>
</tr>
<tr>
<td><strong>Delivery</strong></td>
<td>Service blueprinting</td>
<td>Maintenance</td>
<td>Interviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td>program planning</td>
<td></td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td>Interviews</td>
<td>Maintenance</td>
<td>Interviews</td>
</tr>
<tr>
<td></td>
<td>Program planning</td>
<td>LCC</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 8. SMARTADVANTAGE METHODS IN THE MODEL OF SERVICE INFORMATION REQUIREMENTS**
The first results of the SmartAdvantage project are presented above, describing the opportunities and barriers at a generic level, case studies for each of the project partners and the potential utilization of previous research results. The opportunities of digitalization will be further analyzed during the next phase of the project, and the results of this analysis will be utilized as guidance for the rest of the project.

The work will be continued in collaboration with our partner companies. The next phase will gather information on the applications of existing methods, models and tools. This will include creating novel digitalized asset management solutions for the selected applications and markets.

The SmartAdvantage project aims to identify generic knowledge and experience that will assist a wide range of Finnish companies to exploit the opportunities of digitalization and create new international businesses. These contributions will be shared in the next SmartAdvantage publications.
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Towards Smart
Data-oriented Services