acatech STUDY

acatech Maturity Index Smart Services

Shaping the Transformation of Businesses to Smart Service Providers

Roman Dumitrescu, Frank Riemensperger, Günther Schuh (Eds.)

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I4.0 MC Industrie 4.0 Maturity Center
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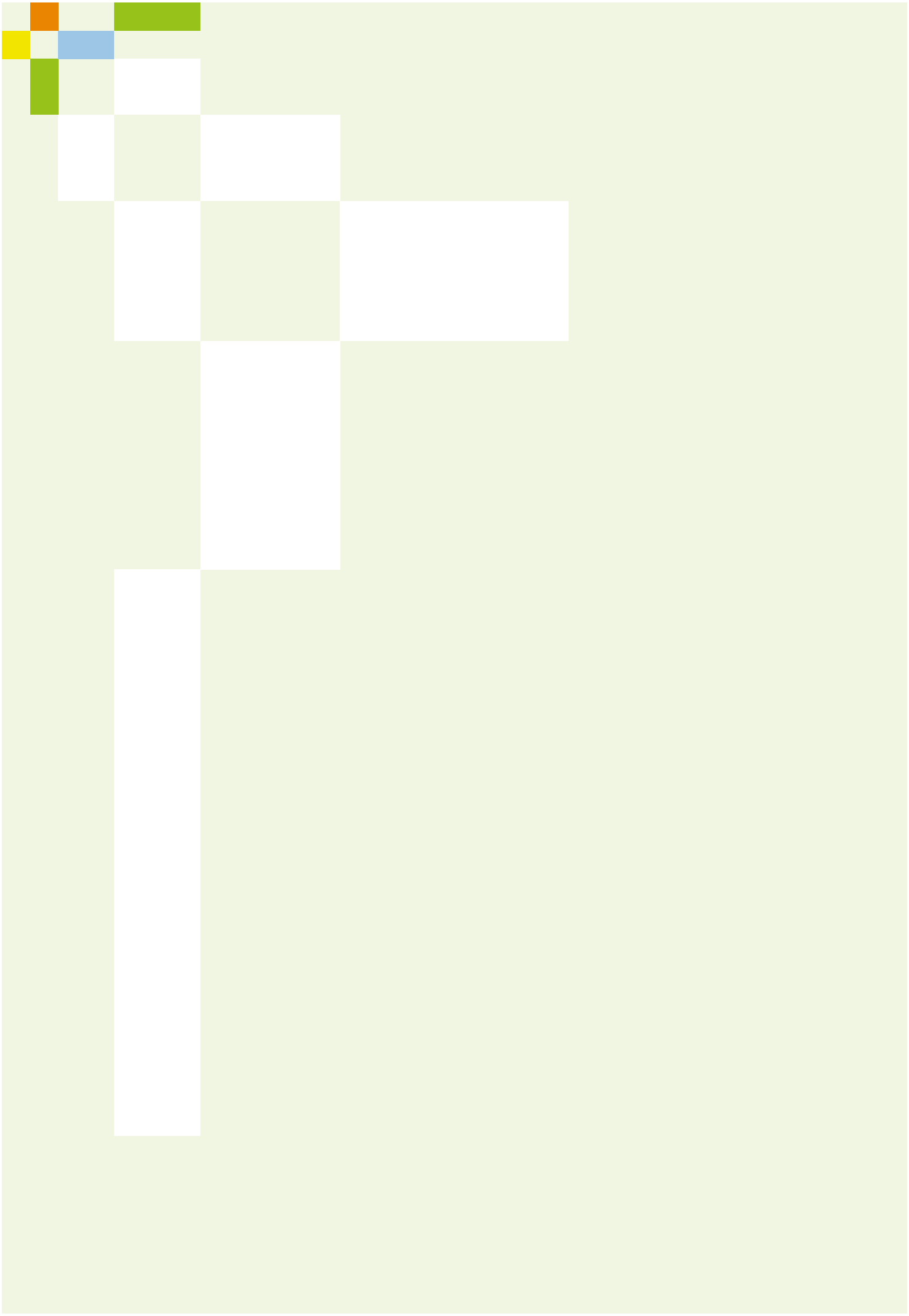

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Foreword

The Industrie 4.0 and *Smart Service Welt* vision is clear, a combination of smart products and data-based services leads to product improvement. When this is brought together with value-driven, service-oriented value propositions, new market opportunities open up. For example, the product "intelligent car", complemented by the service "autonomous driving" in conjunction with the value proposition "safe journey and arrival" will turn entire industries upside down.

The *Smart Service Welt* vision remains as attractive as ever. However, as sometimes sluggish implementation in recent years has shown, the market success of smart services depends not just on a combination of product and service, but on an effective triad of product, service and customer-oriented value proposition to create real differentiation and entirely new market opportunities.

The progress made in digitalisation now offers new potential for strengthening this triad. Cloud and edge solutions are gaining ground, the data trove is growing and, in the future, the emerging industrial metaverse will also be able to include entire ecosystems with comprehensive data offerings for developing smart services. Three factors are crucial here:

- We need convincing use cases which illustrate the economic and social value of smart services. "Autonomous driving" is one of many examples. Personalised medicine (e.g. in cancer treatment), which is adapted to the individual during the course of recovery and includes the value proposition "regaining health", is another example of a smart service which has revolutionary potential.

- Making value propositions personal and delivering on them brings differentiation opportunities and massive new business potential. Products and services lacking a value proposition which is relevant to people simply fizzle out. This probably explains why the internet-connected refrigerator with automatic reordering has never caught on.

- An ecosystem approach is required for developing competitive smart services. In the industrial metaverse, it is no longer enough to develop smart services based on product data. Ecosystem data and the use of artificial intelligence and autonomous algorithms make the difference, ensuring that smart services can adapt to their environment and to customer needs. Achieving this means that businesses need to understand not only their customers, but also the ecosystem, and to be open to creating shared value on the basis of shared data. This also includes sharing some of the newly created value.

The challenge now is to combine the building blocks of product, service and value proposition into sustainable and competitive smart services and to create successful business models. Even the big players will struggle go it alone, but Germany as a centre for innovation also depends on its hidden champions, small and medium-sized companies. The acatech Maturity Index Smart Services is intended to make this overall picture practically applicable with the explicit aim of enabling businesses to provide smart services.

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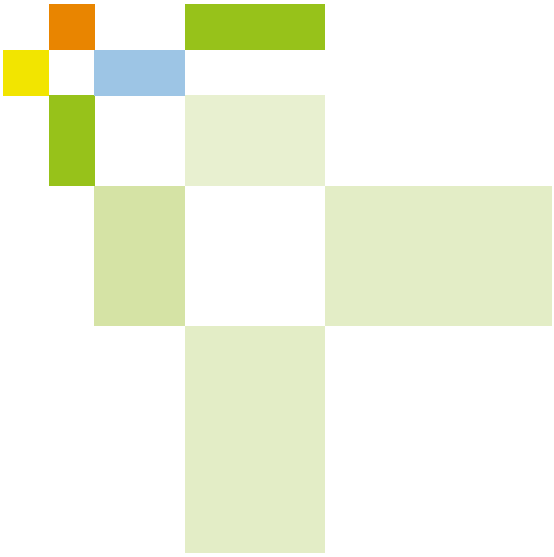

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Executive Summary

The acatech Maturity Index Smart Services which is presented in this study was developed with the aim of providing manufacturing companies with support for shaping the transformation processes required for successfully expanding their service portfolio to include smart services.

The guidance is structured as a six-stage maturity model in which each individual stage of development promises an increase in benefits. Six key structural areas were identified during the design of the acatech Maturity Index Smart Services: Product & Connectivity, Service & User Experience, Business & Ecosystem, Technology & Data, Organisation & Management, and People & Culture, each area being assigned two characterising principles. For each area, capabilities were in turn defined which a business and its staff should have if they want to expand their service portfolio to include smart services and align their organisation, structure and processes accordingly. A questionnaire is available for assessing the maturity of the required capabilities in the organisation. There are two to six gradations per capability which express the respective maturity level. The capabilities and their (maturity) levels can also be used not only to define goals but also to derive concrete measures, i.e. to determine which activity will help the business move up to the next level.

The acatech Maturity Index Smart Services additionally enables manufacturing companies to develop a precisely tailored digital roadmap for them to use as the basis for introducing smart services and so make the transition to a learning, agile organisation. The maturity model is based on the acatech Industrie 4.0 Maturity Index[1] and adopts the latter's approach (see figure 1).

For instance, offering smart services presupposes that manufacturing companies have begun their digital transformation process and are implementing Industrie 4.0 in terms of creating digital factories so that they can build on these foundations to servitise their service portfolio. The complementary structure of the acatech Maturity Index Smart Services and the acatech Industrie 4.0 Maturity Index thus permits a modular and incremental design of the digital transformation and servitisation of manufacturing companies.

Figure 1: From the Industrie 4.0 Maturity Index to the acatech Maturity Index Smart Services (source: own presentation)

1 | See Schuh/Anderl/Dumitrescu/Krüger/ten Hompel 2020a, b.

1 Introduction

For decades, manufacturing companies have been the driving force and engine of innovation and prosperity in Germany, especially in leading industries such as mechanical engineering, electrical engineering and the automotive sector. "Made in Germany" is a quality mark and products bearing it are often huge export successes of internationally renowned quality.

But Germany cannot rest on yesterday's laurels, it must keep moving forwards: companies must develop their own vision of how they can leverage digitalisation and its associated opportunities in order to survive in an increasingly competitive market environment in the future. Hugely dynamic progress and the resultant complexity demand faster and better decision-making processes from companies. In many cases, however, today's reality fails to live up to this need.

In the course of digitalisation, a new data economy has emerged in the 21st century, enabling innovative service-oriented digital business models which are platform- and data-driven. The B2C sector is dominated by providers from the USA or China known as "hyperscalers" who now have an almost unassailable lead. In the manufacturing-oriented B2B environment, however, German companies still have an opportunity to help shape the data and platform economy, to reinvent "Made in Germany" and to consolidate and expand their position in the global competitive arena: smart services, i.e. data-based services, offer opportunities to combine excellent products with excellent services. These complement the range of purely physical products and make it possible to respond flexibly, individually and specifically to customer wishes and expectations[2]. This is one of the findings of the German Federal government's *Smart Service Welt* project: customised, data-based smart services are often more important than the product itself. They are thus replacing the previously dominant physical products and generic off-the-shelf services as the most significant differentiators. Companies offering smart services define their relationship with customers and can involve them in all aspects of the co-creation of services via collaborative processes.

Servitisation of a company's portfolio of products and services entails wide-ranging adjustments within the company, in particular with regard to its business model. The significance of digitalisation in manufacturing companies has been extensively discussed in the context of Industrie 4.0, which describes digitalisation in industrial production. Many companies have recognised the implications of this, and some of them have embarked on the path of transformation. Doing so is vital for implementing successful smart services offerings. Digital connectivity of production facilities and products is essential for Industrie 4.0 and not only ensures faster and more efficient manufacturing processes, but also holds further potential for the design and implementation of new business models. Products connected via the internet (smart products) are the basis for creating new offers or value propositions for customers in the form of data-based smart services, and for introducing new service-oriented revenue concepts (see figure 2). However, such disruptive business models are still (too) rare. Most players are indeed well aware that there are great opportunities in customising and personalising services. Nevertheless, many businesses are not implementing this knowledge in their own corporate practice. This is because the companies lack the necessary skills, resources and structures, resulting in comparatively long innovation cycles.

In addition to the necessary technologies for ensuring smart product connectivity, a successful transformation to a smart service provider consequently also requires adjustments to internal and external processes as well as a suitable corporate structure supported by innovative members of staff. Such far-reaching transformation processes require a continuous, progressive approach which proceeds function by function and department by department. On the other hand, it is also important to quickly generate measurable results in this process, learn from them and promptly integrate these findings into the transformation process. This requires a systematic approach.

2 | See acatech 2018, p. 50.

The acatech Industrie 4.0 Maturity Index provides manufacturing companies with a blueprint and a practical tool for introducing and expanding Industrie 4.0 in a structured manner. Similarly, there is a need for a smart services toolkit which helps companies to systematically make the transition to smart service providers. This is intended to enable them to identify an advantageous position in the *Smart Service Welt* and indicate ways to tap into it. The aim of this publication is to contribute to revitalising "Made in Germany" for the 21st century's servitised data economy.

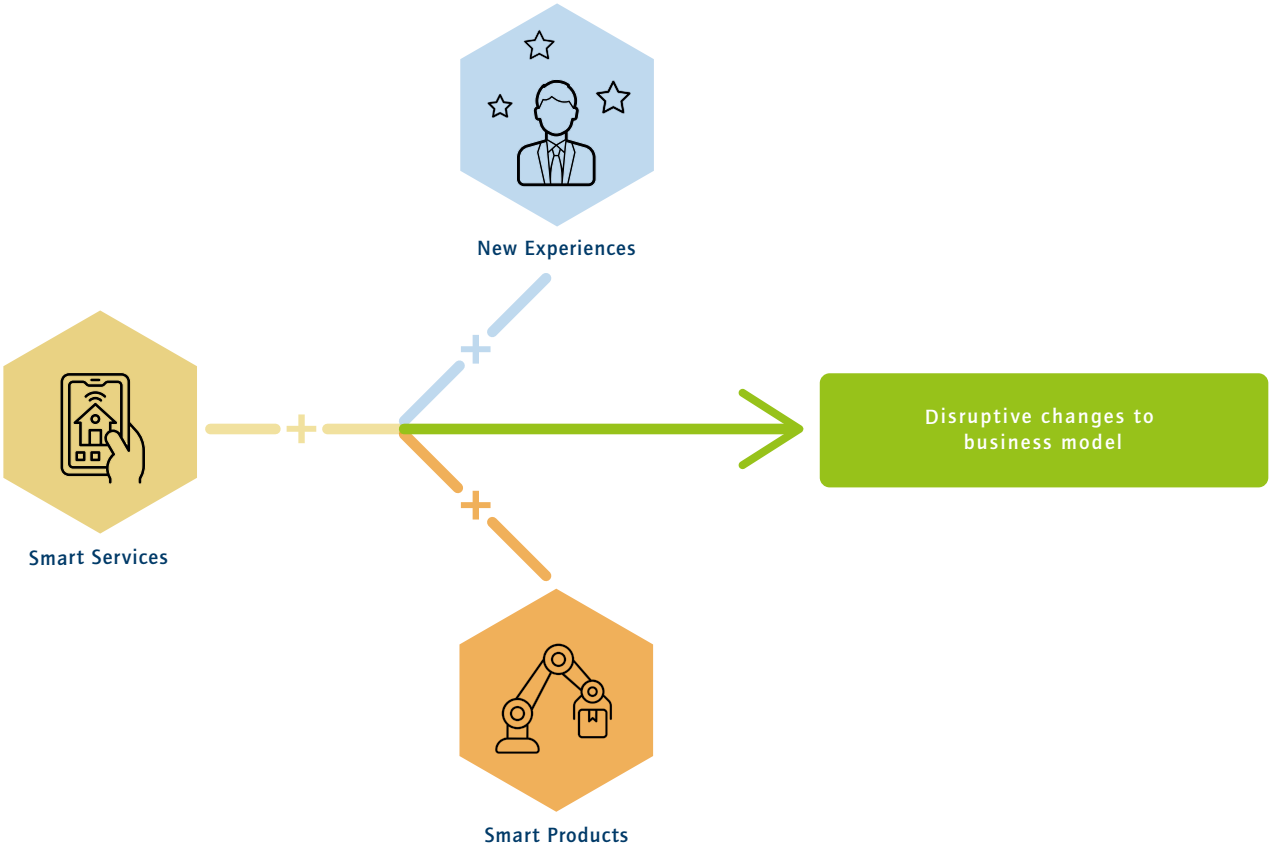


Figure 2: Smart services as business model disruptors (source: acatech 2018, p. 26)

2 Objectives and Methodology

The aim of the acatech Maturity Index Smart Services presented in this STUDY is to provide manufacturing companies with a toolkit which enables them to successfully transition to being a smart service provider, a process which proceeds in a number of steps. The first step involves determining the company's current maturity level with regard to smart service business. On the basis of this and the company's strategic goals, a target maturity level is defined in a second step. To close the gap between the actual and target maturity levels, companies must then derive suitable measures in a third step and structure them in a roadmap. This process enables companies to build and expand a promising smart service business to remain competitive in the future.

One essential feature of the acatech Maturity Index Smart Services methodology is an understanding of the company as a sociotechnical system which means that a successful transformation must take account of more than just the technological aspects of smart services. Organisational and people-related aspects or structural areas must also be included. The acatech Maturity Index Smart Services enables manufacturing companies to take this holistic view of their organisation and the transformation process to being a smart service provider.

The development of the acatech Maturity Index Smart Services followed an iterative procedure in which the project team members were guided by the development of maturity models according to Becker et al. (2009)[3] and thus by the fundamental phases of design-oriented research. Based on Österle/Otto (2010)[4], the methodological procedure, shown in figure 3 and described in detail below, essentially comprised four phases: analysis, design, evaluation and dissemination. Iterative loops were provided within and between the individual phases to ensure consistency.

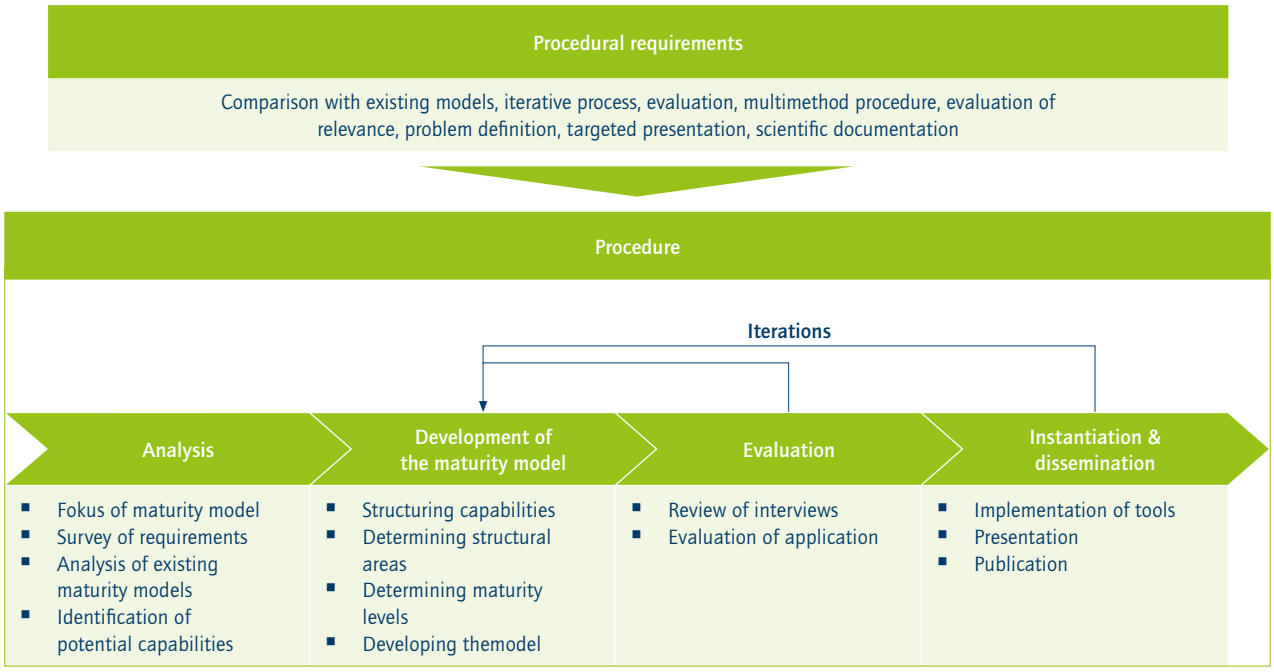


Figure 3: Methodological procedure for developing the acatech Maturity Index Smart Services (source: own presentation on the basis of Otto/Österle 2012)

3 | See Becker/Knackstedt/Pöppelbuß 2009.
4 | See Österle/Otto 2010.

2.1 Analysis

The aim of the first phase was to define the content and structural basis of the maturity model. This was done both in the context of consortium workshops and in the form of literature reviews and expert interviews. First of all, the basic orientation was determined. Project team members then analysed existing maturity models, surveyed relevant real-world requirements and issues, and identified necessary capabilities for a successful smart service transformation.

The focus of the maturity model developed as part of this project defines the users and goals addressed by the model. To this end, a workshop was organised and conducted in which the project team members were able to contribute their experience from their previous projects on smart service transformation and defined the following framework or objectives, namely that the maturity model should primarily focus on manufacturing companies. Further relevant stakeholders in the smart service ecosystem, such as IT service providers, are not included in the analysis at this stage because they differ too much from manufacturing companies in terms of the transformation of business models and processes. The goal of the maturity model should be to provide companies with a suitable toolkit for a comprehensive transformation to a smart service company. This means that the corresponding process should be viewed holistically. This includes a detailed analysis of all relevant structural areas, principles and capabilities assigned to them, these being the key concepts of the maturity model, which are discussed in detail below (see section 3). In order to offer companies a low threshold to entry, it was also decided to make the maturity model, or rather an analysis tool based on it, available in an abbreviated form as a Quick Assessment, i.e. a tool for rapidly evaluating the current situation in the transformation process.

The requirements for the maturity model were then determined and existing maturity models analysed. The capabilities of relevance to a smart service transformation were identified using an iterative mixed methods approach. The data collection process is firstly described below, followed by the data evaluation procedure.

Data collection

Data collection was based on a comprehensive web search, a systematic review of the relevant literature, and an interview study designed and implemented for this project. The aim of the web search was to identify existing practically oriented maturity models relating to digital transformation, the internet of things (IoT), servitisation and smart services. In total, some 50 maturity models were identified.

The systematic literature review was based on the guidance provided by Webster/Watson (2002)[5] and Xiao/Watson (2019)[6]. Members of the project team firstly selected relevant databases and, using suitable search strings, identified relevant papers and then analysed them at title, abstract and keyword level. The literature search focused on two aspects and thus two clusters of search strings. The first cluster concerned, among other things, the requirements, challenges and potential of a smart service transformation. This search provided the basis for defining the required capabilities. The second cluster related to further scientific maturity models and the question of the conditions under which they can be applied. The identified publications were then reviewed by three smart service experts and their content was checked. As a result, some 40 publications on smart service transformation were selected and then analysed in greater detail.

In parallel to the literature review, project team members conducted semi-structured expert interviews on the basis of guidance prepared for this purpose. The guidance addressed questions of organisation, people, technology, maturity and specific changes. In total, interviews were conducted with 16 experts working for both small and medium-sized enterprises and corporate groups as well as renowned research institutions. The interviews, which lasted some 45 to 60 minutes, were conducted remotely and recorded for later analysis. The recorded interviews were subsequently transcribed according to scientific standards.

Data evaluation

The publications and transcripts were analysed in greater depth to evaluate the data. For this purpose, three project members first coded the texts inductively, i.e. they identified all substantive statements, determined key themes and, on this basis, defined categories into which the statements were classified. This resulted in a coding system which the project team members then supplemented with insights from an analysis of existing maturity models.

This step of the process revealed that most of the maturity models could not be easily applied to smart services. Nevertheless, they provided helpful insights into the required capabili-

5 | See Webster/Watson 2002.
6 | See Xiao/Watson 2019.

ties which could be incorporated into the acatech Maturity Index Smart Services. In contrast, those maturity models which did explicitly consider smart services led to a highly aggregated viewpoint which is insufficient to develop a practical toolkit in the light of the objectives selected for the purpose of this project. They did, however, provide indications of relevant capabilities for the project. The identified potential capabilities were likewise analysed by three project members, reviewed and integrated into the resultant coding system.

At the end of this step of the project, a consortium workshop was held where the project team members discussed and finalised the coding system. As a result, a total of 78 relevant capabilities, which are disjoint and exhaustive, were identified for smart service transformation.

2.2 Development of the maturity model

The second phase involved designing and developing a smart service maturity model and a methodological procedure for using it. This was mainly done in the course of consortium workshops which gave project team members the opportunity to contribute their subject and application knowledge. This step was based on the capabilities and fundamental requirements with regard to the applicability of the maturity model to manufacturing companies (see the explanations relating to the first phase in section 2.1). For greater clarity, the 78 identified capabilities were firstly thematically clustered and structured and, over a number of iterations, six well-defined structural areas were specified.

In order to be able to assess the maturity of the capabilities, during workshops the project team then defined six representative maturity levels, which represent archetypal development stages on the path to becoming a smart service provider (see section 4). These stages were based both on practical reports from organisations that have already embarked on the path of transformation and on theoretical principles of corporate transformation, ecosystems and smart services.

In order to be able to map these generic maturity levels onto the necessary capabilities, the project team members also developed concrete issues to be addressed for the respective capabilities and representative responses in a maturity context. This resulted in a six-level maturity model which in turn refers to six structural areas and is backed up by appropriate questions for the identified 78 capabilities together with possible responses for the generic maturity levels.

The maturity model is thus applied on the same basis as the established approach of the acatech Industrie 4.0 Maturity Index which was also adapted to smart services in workshops with experienced assessors.

In order to provide companies with a low threshold of entry into analysing the progress of their transformation, the project team developed an abbreviated version of the maturity model and the application methodology based on it. To this end, in the course of a workshop, the members of the project group prioritised the previously defined capabilities and issues which are of particular significance to a smart service transformation. These form the framework for a Quick Assessment, a compressed version of the smart service maturity assessment. A total of 24 capabilities and the associated issues were included in this Quick Assessment.

In addition, suitable policy recommendations for the maturity levels of the structural areas were developed in numerous expert workshops. These policy recommendations offer companies a generic direction for further refining their smart service transformation.

The outcomes of the second phase are thus the acatech Maturity Index Smart Services, a methodological procedure for applying it, as well as a Quick Assessment.

2.3 Evaluation

The aim of evaluation was to establish whether companies can easily apply the acatech Maturity Index Smart Services under real-world conditions and whether the toolkit is complete. To this end, the project team conducted review interviews and pilot applications. The interviews with 19 smart service experts confirmed that the selected structural areas and capabilities were practically relevant and meaningful. Individual comments on capabilities and wording were iteratively incorporated into the model.

To ensure that the maturity model can also be applied under real-world conditions by different organisations, it was trialled

in on-site pilot applications in three companies of different sizes: one small, one medium-sized, and one corporate group. The resultant insights and feedback were incorporated into the further development of the toolkit.

The outcome of the third phase was thus a scientifically sound and validated version of the acatech Maturity Index Smart Services.

2.4 Dissemination and instantiation

The aim of the fourth phase was to make the project results available to the public. The project team with acatech as consortium lead organised an event on the occasion of the launch of the acatech Maturity Hub Smart Services[7] and presented the maturity model and the developed toolkit to an interested expert audience, specifically representatives from business practice. The participants discussed the structural areas of the maturity model in a World Café workshop and clearly stated that they found both the design of the structural areas and the capabilities to be fit for purpose. This provided additional validation of the results. In addition, the project team members introduced the Quick Assessment and released it to the general public as a software tool. It is available online on the freely accessible acatech Maturity Hub Smart Services, where the project's key results are also described.

In order to carry out further, more in-depth or assisted assessments under real-world conditions, the project team has set up a platform for applying the acatech Maturity Index Smart Services. This platform is based on the rationale and structure of the existing and established Industrie 4.0 Maturity Index platform and is designed as a support tool for preparing and following up assessments. It also assists with calculating and documenting a company's maturity.

This acatech STUDY is also intended to play a part in providing a comprehensible description of the development of the acatech Maturity Index Smart Services and making the project's insights available to a specialist audience. The following sections provide a detailed description of the model's structure (section 3), the maturity levels (section 4), the structural areas and associated capabilities (section 5) and the procedure for applying it (section 6). Further scientific publications are at the planning stage.

7 | Available from: https://acatechmaturityhub-smartservices.de.

3 Model Structure

The toolkit developed in this acatech STUDY takes a model-based approach which allows a focus on the solutions and benefits at the various stages in the development of smart services and supports companies throughout the transformation process, starting from the prerequisites which have to be put in place at the outset and continuing until a smart service business has been implemented. Using the maturity model, companies can firstly determine their actual status and define their target status. The desired target status is always dependent on the particular business strategy and is determined individually for each company, the optimum target status not necessarily being the maximum possible. Instead, companies should define a target which is in line with their basic plans for growth and turnover. It should always be kept in mind that changes to corporate strategy or the regulatory framework in the market may make it necessary to redefine the target level. Finally, a comparison of the actual and target statuses shows companies how great the need for action is and where changes have to be made.

The acatech Maturity Index Smart Services was developed with the aim of providing manufacturing companies with a practical framework for structuring their overall transformation into smart service providers. The required process steps and concepts are clearly defined.

The six structural areas of the maturity model enable a comprehensive overview of corporate transformation with two guiding principles being defined for each area. In turn, these are assigned specific capabilities which a company needs to develop in order to establish a smart service business (see figure 4).

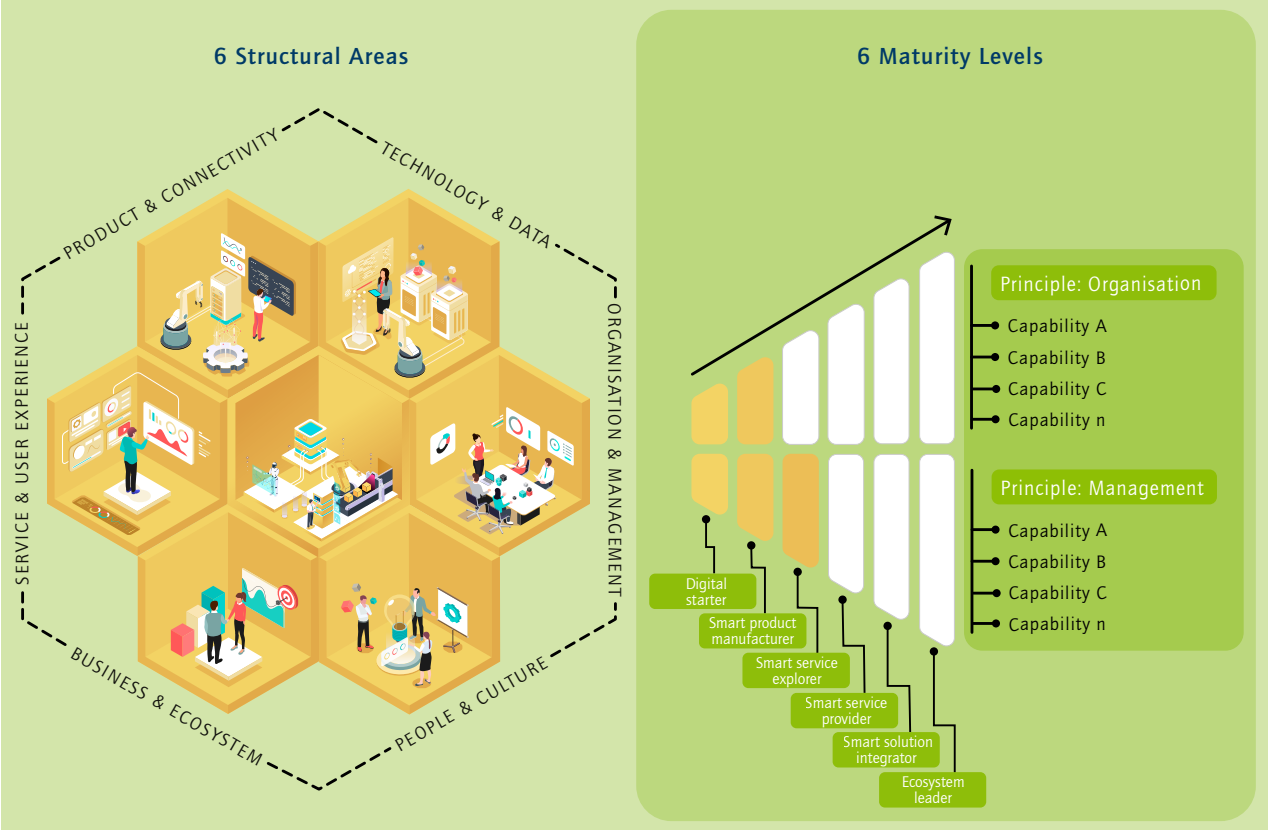


Figure 4: Structure of the acatech Maturity Index Smart Services model (source: own presentation)

4 Solution- and Benefit-oriented Development Stages

Manufacturing companies wishing to integrate smart services into their portfolios must simultaneously servitise and digitalise. This requires staff with the appropriate capabilities and skills. Simultaneous servitisation and digitalisation entail changes across broad parts of the organisation. The associated complexity means that relatively long-term transformation processes, usually lasting several years, are necessary. In order not to lose sight of the defined goals in this transformation process, it should at all times be clear to every member of staff and stakeholder that the company's profitability and future viability are dependent on growth in the new business areas. The benefits of transformation should therefore be communicated transparently at all times. In addition, companies should design the transformation process in such a way that there are continuous positive effects on profitability, i.e. on growth and the development of new business areas. One challenge is to grab quick wins along the way while also working on higher-level transformation goals. This is precisely what the maturity model developed as part of this study and the toolkit based on it are intended to make possible.

Companies pass through a number of characteristic development stages in their transformation to smart service providers. The acatech Maturity Index Smart Services describes a prototypical development pathway from conventional manufacturing company to fully integrated smart service provider. This pathway accompanies companies from the point at which they lay the foundations for offering smart services to the point at which they have found their role as shapers of digital service ecosystems and positioned themselves accordingly in the market. This pathway passes through six successive development stages (see figure 5). The stages describe the concrete benefits for the companies and define the capabilities required for transformation.

If transformation is to be successful and sustainable, it is important for companies to build their capabilities continuously and incrementally. The further a company's development has pro-

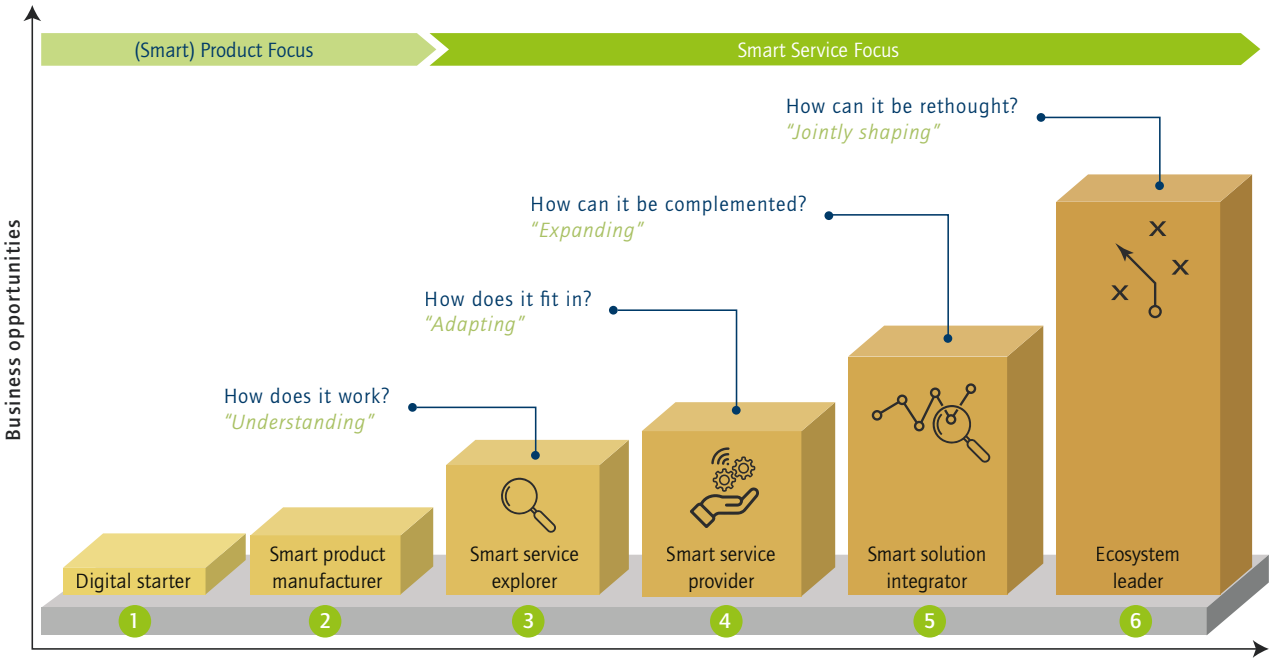


Figure 5: Maturity levels of the acatech Maturity Index Smart Services model (source: own presentation)

gressed, the stronger must its capabilities be. In this process, companies must take care to develop capabilities evenly across the relevant functions. For instance, a high level of maturity in the servitisation of internal company processes is of little use if the business model is not also appropriately focused on smart services. Companies should here individually determine for themselves which development stage provides the best cost-benefit ratio and should be at the end of the planned transformation process.

The lowest level of the maturity model is stage 0, which covers companies that can be described as digitally stagnating, with no awareness of the need for digitalisation. This level is not represented in the maturity model, because such companies cannot be assumed to be aspiring to a smart service transformation and may therefore also have no interest in the acatech Maturity Index Smart Services. Stage 1 (digital starter) and stage 2 (smart product manufacturer) are also not yet explicitly addressing smart services, but are looking at the essential prerequisites, i.e. digitalisation of the product and the company. The next levels, 3 to 6, deal with building specific capabilities which are required for smart services.

The six development stages of the acatech Maturity Index Smart Services are described in detail below. It should be borne in mind that these are archetypes, so even if a company as a whole is assigned to a development stage, it may deviate significantly from the archetype in some structural areas.

4.1 Digital starter

The starting point for the development pathway and the basis for servitising a company's offer is the fundamental realisation that digitalisation of the organisation and adjustments to its service portfolio have to be tackled if the company is to survive competitively in the future. Such manufacturing companies are aware that success requires them to face up to the challenges of digitalisation and the mechanisms of the data economy: many of them acknowledge that smart products and smart services are fundamental in this context, but implementation presents challenges for some.

These companies are at the first stage of the maturity model and are referred to as digital starters. They already have a fundamental awareness of the need for smart service transformation, but for various reasons have not yet been able to set out to meet the challenges of change. Their products are not yet connected to one another or the internet and have only simple digital functions. Accordingly, data from product operation are also not available. Infrastructure for data analysis and processing is lacking. The service focus is still very much on traditional services such as maintenance contracts. These are frequently barely adapted to a customer's specific needs and are not sufficiently optimised for user experience. This relatively low level of innovation is also reflected in management practice. Innovative approaches are often still met with scepticism. Visions are not set out. Operational processes are geared towards the requirements of existing production procedures which have been followed and practised for many years. The focus in such companies is primarily on optimising existing products and services from an efficiency perspective, but not on developing entirely new applications. Business models are also structured accordingly, with product and service being viewed in isolation. Staff and the corporate culture are completely focused on their own company and, in some cases, entirely on their own function. Interdisciplinary working is not put into practice.

4.2 Smart product manufacturer

This second maturity level describes companies which have reached an advanced stage of implementation with regard to Industrie 4.0. They do offer products with digital functions but, despite these products being internet-connected, these companies have not yet tapped the potential for smart services. Companies at maturity level 2 are consequently referred to as smart product manufacturers.

The rudiments of transformation are discernible in these companies, but although they have taken the first steps, the process faces multiple obstacles. For instance, these companies' smart products are generally capable of acquiring data. Often, however, these are just simple data relating solely to product status and, as such, are less informative. In addition, the companies often cannot access these data because only a few customers enable data feedback to the manufacturer. The companies have already put the initial pieces of a tech stack in place and have the capability to carry out simple data analytics on projects. However, the data are not yet put to standardised and systematic use for the service. On the other hand, these companies usually have valuable fundamental knowledge about product use and can offer higher-value services, such as process consulting, based on this knowledge. While responsi-

bilities for digitalising products and services have indeed been defined, operationally they have their limits. More innovative concepts are increasingly being applied to the business models in these companies, for example by linking products and maintenance in service bundles. While the beginnings of interdisciplinary collaboration are in place, its benefits are not yet clear to all stakeholders.

4.3 Smart service explorer

Smart service explorers are already capable of developing and trialling initial smart service concepts. However, these are not yet commercially available, but are instead being worked out and tested on an exploratory basis with pilot customers as part of research and development collaborations. The challenge for these companies is in particular obtaining the correct data in sufficient volumes for their new services. In addition, they often find it difficult to use the data they do have in a way that is beneficial for new services which are being developed. Companies addressing these issues are located at the third maturity level.

Thanks to their smart products, these companies are often already able to acquire a wide range of data from processes or statuses. They generally provide their customers with update and upgrade solutions. Using the IoT interface and a simple tech stack, the companies thus have limited access to some of the products in the field. This allows them to evaluate data using simple, descriptive analyses which are generally carried out manually. The analyses enable these companies to align the targeted smart services more closely with user needs, but these data insights cannot yet be used to put new services in place. Management has already prioritised use cases and approved them for trial. The necessary structures and processes have been defined and implemented on a rudimentary basis. The interactions between product and smart service business model are being analysed and trialled. Individual members of staff are developing skills which are needed to expand smart services and bringing these new skills together with the existing skills of specialist departments in projects.

4.4 Smart service provider

Companies at this maturity level have initially trialled smart services and identified them as a promising opportunity, having been able to clearly identify the added value for their customers. They have brought their first smart services to market and can consequently be described as smart service providers. They have created a triad of smart product, smart service and customer-centric value proposition. These companies often serve specific market niches, such as condition monitoring for their products. Smart service providers at maturity level 4 primarily use smart services to round out their portfolio. A complete transformation from manufacturing company to a primarily service-dominated organisation has not yet taken place.

The smart products provided by the companies at this maturity level are acquiring ever greater volumes of data as a result of additional sensors or interfaces being implemented on these products or retrofitted to those already in operation. Many customers are making use of the products' IoT capability. The companies' backend has a standardised tech stack available to process these data and develop, operate and bill smart services. These well-developed processes enable these companies to comprehensively collect data, as well as automate and continuously study them using advanced analytics. The companies have developed a strategy and visions for their smart service transformation and embedded them in their organisational structure and processes. These also include key processes for a smart service business. Staff have become familiar with the process of transformation towards being a smart service provider, are appropriately qualified, and are driving the relevant developments cross-functionally using their own initiative.

4.5 Smart solution integrator

Further professionalising and expanding smart service business leads the smart service provider to become a smart solution integrator. Companies which have successfully linked their products and services with digital business models to form complete solutions and thus offer smart services across niches and markets are to be found at this fifth maturity level. These companies have already made extensive adjustments across the enterprise.

These companies' smart products acquire all the data relevant to customer value creation. The companies have implemented retrofits and updates in the products. Most customers accept access to the data via the IoT interfaces and also allow the manufacturer to carry out (limited) adjustments during operation. The standardised tech stack is correspondingly powerful. The companies are increasingly able to carry out even more

complex, AI-based analyses and cover predictive use cases. They have already brought integrated product and service solutions to market. In doing so, they have not only bundled development activities, but also created appropriate sales and service structures which bring smart services to market. Processes and interfaces with partners and customers are defined and well documented. Management has developed clear visions and appropriate indicators which give direction and consistency to its decisions. Those in charge of the smart service business are developing the business strategically on the basis of these visions and are putting it into practice (even in the face of resistance). Customers are benefiting from clearly defined solution packages and transparent prices, receiving precisely the service packages they need to achieve their individual goals.

4.6 Ecosystem leader

Companies which are shaping the entire market environment with their services are referred to as ecosystem leaders. This is the highest development stage of the maturity model. Together with customers, partners, and in some cases even competitors, these companies develop smart services for entire (digital) ecosystems. This enables them to tap into potential benefits that would not be achievable for them as an individual company. This approach is associated with numerous requirements and challenges, but also opens up enormous opportunities. The advance of digitalisation in manufacturing has opened up entirely new possibilities for use cases, among other things with the emergence of the industrial metaverse[8] and the advent of data ecosystems, for instance based on GAIA-X[9].

At this maturity level, the focus is not only on the company's own smart products, but also on all systems and stakeholders relevant to customer value creation. The IoT-connected smart services run on the company's own products, those of cooperation partners or even competitors. Companies will often have created IoT platforms connected to the tech stack that provide further platform-agnostic interfaces for this purpose. This enables them to merge and analyse heterogeneous data from different processes and stakeholders, for which powerful algorithms are available. The derived results are aggregated and monetised in a portfolio of the company's, and in some case third-party, services. These companies can offer customers new individually tailored total packages and services, such as live benchmarking.

The business or entire business units of these companies are firmly focused on smart services. Within the companies, smart services are regarded as at least equivalent to the traditional (product) business. The organisation is customer- and ecosystem-centric, something which is also lived out in the processes. Smart services have a well-established place in corporate strategy, with top management regarding them as an essential competitive factor. This has a positive effect on recruiting specialist staff. Companies at this maturity level attract appropriate talent that wants to become part of an interdisciplinary innovation system. Customers also benefit from this.

Few companies will succeed in setting up an entire ecosystem for smart services, i.e. manufacturer-to-X relationships, for example with customers, other manufacturers, suppliers, or non-profit partners. Only those companies that do so successfully are located at the highest maturity level.

8 | See also Plattform Industrie 4.0, 2023.
9 | See also Kraemer/Niebel/Reiberg 2023.

5 Structural Areas for the Smart Service Transformation

The acatech Maturity Index Smart Services identifies how companies' transformation is progressing along six defined structural areas, each of which is characterised by two associated principles. A number of specific capabilities are assigned to these principles. Capabilities in the six structural areas Product & Connectivity, Service & User Experience, Business & Ecosystem, Technology & Data, Organisation & Management and People & Culture are considered.

The first three structural areas have a direct impact on the market offer. The final three structural areas enable the fundamental deliverability of this market offer and are thus the basis for value creation. They primarily target internal operations that are essential to the delivery of smart services. A suitable technology and data basis is the prerequisite for the development of smart products and, once these factors have been skilfully brought together, they enable companies to develop customer-centric services with an outstanding user experience. If this is to be achieved, Organisation & Management must create the structural and procedural prerequisites for creating smart services. In the smart service triad, customer orientation and the associated high benefit and value proposition play a central role alongside the product and the service. Customer orientation arises when business models are constantly reviewed and adapted (Business) and the company sees and positions itself as an ecosystem designer and orchestrator (Ecosystem). This requires an organisation to have staff with skills including a well-developed service mindset, customer orientation and openness to innovation (People) and that these attributes are embedded in the organisation's values (Culture).

The six structural areas thus have an interdependent, complementary relationship with each other and form the building blocks of successful smart service transformation. They are con-

Figure 6: Structural areas of the acatech Maturity Index Smart Services model (source: own presentation)

nected over the six stages of the smart service development pathway in the smart service transformation hexagon (see figure 6).

Two principles which guide further development are assigned to each structural area. Each principle in turn bundles key capabilities that must be successively built up in line with solution- and benefit-oriented development stages. The levels of implementation of the respective capabilities are recorded and aggregated to determine the maturity level of the principle. A weighted average of the maturity levels of the two principles form the respective value of the structural area.

Key capabilities for each structural area are presented below. In practice, the maturity assessment (see section 6 and the acatech Maturity Hub Smart Services[10] for more details) explores significantly more, clearly specified capabilities at finer granularity. For ease of understanding, the capabilities have here been simplified to the key capabilities.

5.1 Product & Connectivity

Smart products, i.e. products that are intelligent enough to acquire and process data and information and to communicate and interact with other systems and devices, are the prerequisite which determines the fundamental deliverability of smart services. This requires extensive connectivity and integration of individual components and the product with surrounding systems, so overcoming physical and digital boundaries. Equal ac-

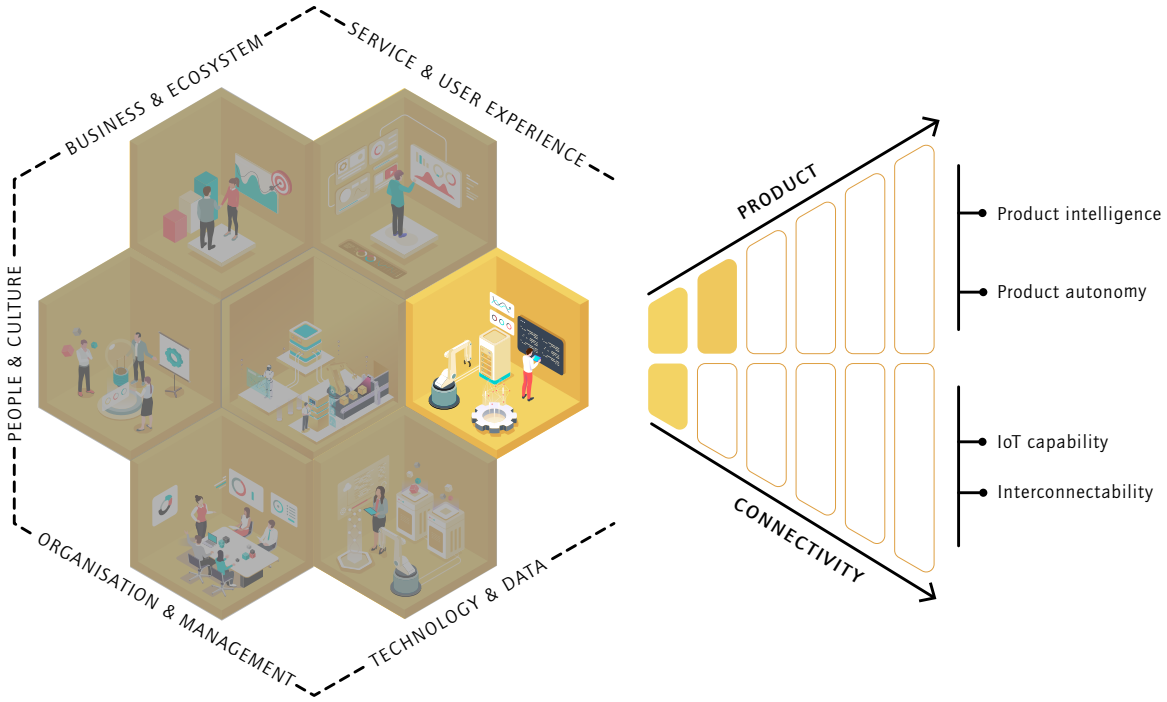


Figure 7: Principles and selected capabilities of the "Product & Connectivity" structural area (source: own presentation)

10 | Available from: https://acatechmaturityhub-smartservices.de.

count must be taken of both the physical product and its connectivity, the two principles which are assigned to the first structural area "Product & Connectivity" (see figure 7).

5.1.1 Product

The "Product" principle relates to the technological capabilities and functions of the physical product which is complemented by smart services. Aspects including the product's intelligence and autonomy are analysed here in order to ensure that the physical product has the necessary capabilities to support smart services effectively and efficiently.

Product intelligence
Product intelligence is critical to developing and delivering smart services. It is the basis for creating intelligent, connected and innovative solutions. Specifically, *product intelligence* is about whether and to what extent a physical product is capable of acquiring, processing and using data and information to optimise its own performance and functionality and so create clear-cut added value for users. This is enabled by integrating components such as sensors, microprocessors and connectivity modules into the physical product. An intelligent product can, for example, independently detect and diagnose errors, automatically optimise processes or offer personalised services. If a product acquires and processes data from the environment or from other systems and devices, it may be able to perform predictive maintenance or respond automatically to changing conditions.

Product autonomy
Further capabilities such as a degree of product autonomy are important for the provision and use of smart services. Product autonomy enables a real-time response to customer needs without the need for manual interaction. An autonomous smart home system based on sensors and artificial intelligence can, for example, automatically optimise energy consumption by adjusting heating and lighting according to user preferences and behaviour. This leads to more convenience, more efficient use of the product, and an overall better customer experience.

5.1.2 Connectivity

The "Connectivity" principle describes the capability of the physical product to communicate with other systems and devices. It is here assessed whether the physical products are IoT-capable and how they connect to surrounding systems. The latter examines whether the smart services can be seamlessly integrated into existing (eco)systems, exchange data and information with other systems and devices and whether it is possible to optimise and customise smart services.

IoT capability
If a physical product is IoT-capable, it is able to exchange data and information with other products, systems and cloud services via the internet. Using IoT technology, physical products can acquire, process and share data in real time in order to optimise their performance and functionality and offer personalised services. This enables companies to implement new business models.

Interconnectability
Interconnecting a product with surrounding systems creates new interfaces. Among other things, this requires protocols, programming interfaces (e.g. application programming interfaces (APIs)), standardised data formats and interfaces to ensure interoperability between different products and systems and to facilitate the integration of smart services into existing business processes and systems. Interconnectability is an essential prerequisite for integrating external data sources and services to extend the functionality and benefits of smart services.

5.2 Service & User Experience

When building the capabilities to develop interconnected products, companies must be able to offer a corresponding smart service. The "Service & User Experience" structural area describes the range of services which are provided to customers and assesses the capability of companies to provide customers with a high-performing smart service portfolio. This structural area also assesses user experience with regard to the smart service throughout the customer journey (see figure 8).

5.2.1 Service

The "Service" principle considers a company's range of smart services, assessing the service itself as well as the way in which it is provided and can be customised.

Service provision
Smart services are generally characterised by high availability, reliability and security. Users can assume that the service is available at any time, anywhere, and that their data is safe and secure. Ensuring this means that companies must develop

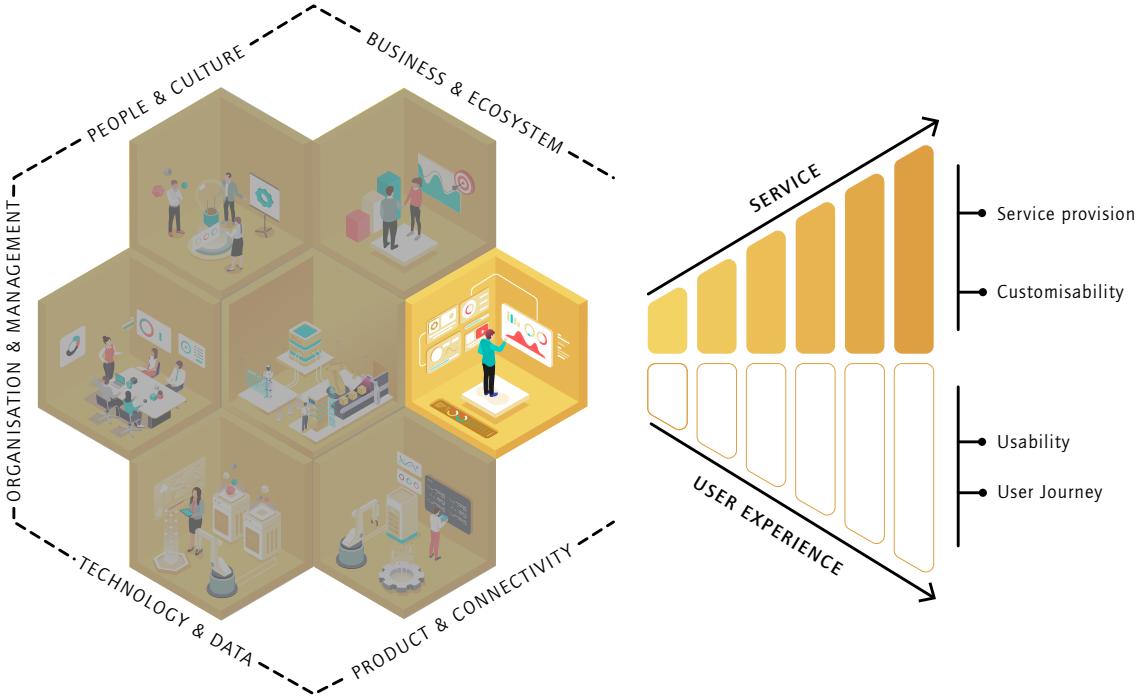


Figure 8: Prinzipien und ausgewählte Fähigkeiten des Gestaltungsfelds Service & Nutzererfahrung (Quelle: eigene Darstellung)

appropriate concepts and draw up requirements for the necessary technological infrastructure. Professional and reliable execution of the smart service is of the essence for users. Companies should therefore be able to respond flexibly to different regulatory frameworks in the provision of services.

Customisability

Whether and how smart services can be customised is another crucial success factor. For the most part, users have individual needs that smart services can address. To meet these demands, providers are called upon not only to enable simple adjustment and personalisation of their services, for instance by the customers themselves by way of individual design options for the user interface, but also to communicate clearly that the service can be tailored to the user's needs. The essential features of this value proposition are availability, reliability and security, as well as the possibility of personalisation and adjustment. This communicates to users that the service is tailored to their individual needs.

5.2.2 User Experience

The "User Experience" principle relates to the specific configuration of points of contact between the user and the smart service. A positive user experience is critical to the success of a smart service. Users are more likely to use and recommend the smart service if it is intuitive and easy to use (usability). Combined with a well-designed user journey, this has a positive impact on overall reach. Usability and user journey development play an essential role here and are examined in greater detail below.

Usability

General ease of use is also known as usability. If a smart service is characterised by a pleasant user experience, for instance due to familiar and intuitive navigation concepts, this can lead to users spending more time interacting with the service, which can lead to higher returns for the company. A further advantage is that users are more loyal in the long run and, once

usage has become familiar, they shy away from familiarising themselves with a new system. As a result, the customer subconsciously becomes committed (locked-in), so also ensuring long-term sales. To be successful, companies should therefore ensure that the user experience of their smart services is simple, intuitive and positive.

User Journey

A deep understanding of its customers is essential for a company to be able to develop customer-centric smart services. Companies should conduct intensive market research to learn about customers' key requirements and problems. The insights gained in the process can then be used to create personas. These are hypothetical representatives of the target groups whose interests and needs are considered by way of example. This method is well suited to gaining a better understanding of customers' specific characteristics and requirements.

Creating a customer journey map is a further important step. This map indicates the points of contact and interfaces between customers and services. Once the customer journey map has been created, attention is in particular paid to the interfaces, customer needs and any problems that may arise. This process enables companies to develop an understanding of potential sources of error and problems and to nip them in the bud.

Testing or surveys are essential to ensuring that the developed smart service does meet customer needs. Real customers should be involved in this process in order to obtain direct feedback and to check how effective the smart service is. The results can then be used to further optimise the smart service.

Overall, a number of steps are required to develop a comprehensive user journey. Nevertheless, the steps should not be viewed as a one-off task, but rather as a process. If companies pursue this process continuously, they will be able to align a smart service with customer needs from the outset and adapt it to them on an ongoing basis because only customer-centric smart service developments will remain successful in the long term.

5.3 Business & Ecosystem

In addition to combining a smart product with data-based smart services to create a comprehensive product-service system, it is important to create a customer-centric benefit and value proposition which is embedded in a service-oriented business model that is aligned with it. Although this is an essential factor in the success of smart services, practical experience shows that many companies still have some catching up to do in this respect. In addition, smart services demand dynamic collaboration with partners, suppliers, customers and even competitors. Only in this way, in interaction with other stakeholders, can new types of smart services emerge which are fully integrated and focused on customer requirements and are not developed without taking market needs into account. These aspects are taken into account as part of the "Business & Ecosystem" structural area (see figure 9).

5.3.1 Business

Business models can be considered from the following different standpoints:[11]

- Target customers: who is to be addressed with the service offering?
- Benefit proposition: what or which benefit is offered to the target customers?
- Revenue and profit model: how are revenues and profit generated?
- Value chain and architecture: how is value created within the company and externally and which players are involved in this process?

The design, development and implementation of smart services require companies to take a critical look at their existing business model and align it holistically with the new requirements of smart service business. The aspects relating to this are primarily addressed in the context of the "Business" principle.

Business model adaptation

Manufacturing companies have traditionally acted as suppliers of products that are delivered to customers. They frequently also offer a greater or lesser degree of support and training for product use. Expanding their product portfolios to include smart services gives rise to completely new and in some cases fundamentally different business model requirements. Close interaction with customers becomes necessary. In contrast to the one-off event of a product sale, this holds great potential for generating continuous returns through usage-based revenue mechanisms. If companies want to offer smart services, they must therefore fundamentally adapt their business model and

11 | See Gassmann/Frankenberger/Csik 2013, p. 6.

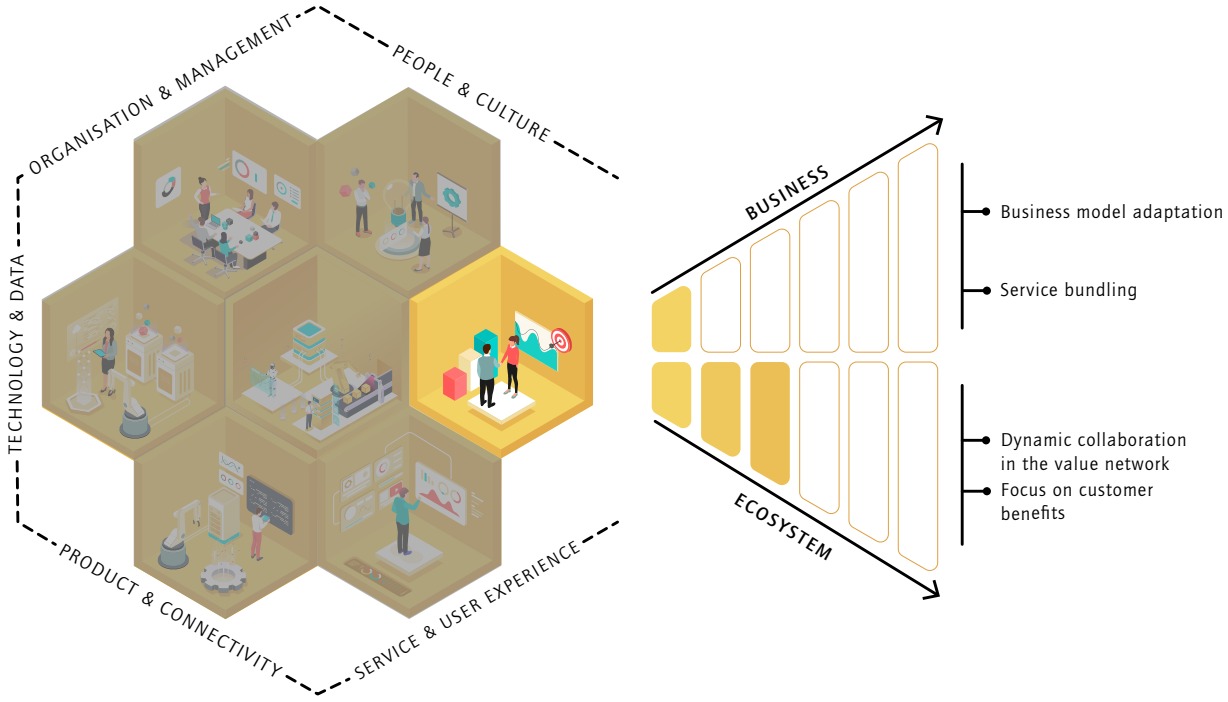


Figure 9: Principles and selected capabilities of the "Business & Ecosystem" structural area (source: own presentation)

design it with the aim of comprehensively servitising the range of services.

Service bundling

Service bundling describes the process whereby companies integrate the physical products and services they offer, place them on the market with associated data-based smart services and so create a customer-oriented benefit and value proposition. Approaches range from simple service bundles consisting of a product and a conventional service to a combination of products with smart services, some of which are also offered jointly with ecosystem partners. If service bundling is to be successful, it must optimally address customer needs, and whether and how this happens depends on industry-specific factors such as these needs or the particular competitive situation.

5.3.2 Ecosystem

The "Ecosystem" principle relates to the market environment. If they are adequately to address market participants' demand for smart services, manufacturing companies must understand how to design and implement dynamic collaboration in value networks within digital ecosystems. This understanding of customers, systems and the industry is essential if the services are to be successful in the long term.

Dynamic collaboration in the value network

Whether and how dynamic collaboration in the value network comes to be a success depends on various factors. One essential factor is the exchange of information. If this proceeds smoothly and automatically between partners, it enables more dynamic collaboration, for example in manual enquiry, ordering and order processing procedures. Operational processes become more transparent through the use of IoT technologies, for instance if all parties involved are informed about current manufacturing status or the quality of the supplier's services.

There are sometimes good strategic reasons for companies to outsource certain manufacturing steps or services. Conversely, they can also offer services in their value network for which

they have built up new skills and know-how. If skills from different partners are systematically combined in this way, this is known as external skills management.[12] Companies which bundle their skills in line with requirements can respond more quickly and flexibly to changing market requirements. In this way, it is possible to develop and offer new smart services jointly and cooperatively which the individual partners would otherwise not be able to implement at all, or only after protracted skills development.

In some markets with less complex, standardised services, for example in logistics, flexible marketplaces are already making their mark. Extensive experience of successful collaboration has been gathered in these markets which provides guidance for newer markets and indicates factors in collaborative success. One factor is, for example, describing the services to be exchanged in as accurate, precise and standardised a manner as possible so that they can be traded. However, achieving this involves effort. It is therefore necessary to set the effort expended against the benefit gained in collaborative projects. If, for example, companies want to work together that have no previous experience of cooperation and there is not yet a relationship of trust between them, it should be carefully weighed up whether this is worthwhile, especially if it is possibly a one-off cooperation. The degree to which companies are able to collaborate is thus determined by their specific skills and experience.

Focus on customer benefits

Smart services give companies an opportunity to respond much more precisely and specifically to customer requirements. This intensifies competition among providers and tends to result in specialisation. The concept of strategic success factors states that a company should clearly focus on a few (key) skills in order to achieve uniqueness in the market.[13] This rationale is becoming even more important as markets become more transparent and value creation is increasingly networked and dynamic. It can be assumed that the dynamic marketplace concept will also become much more relevant. In a transparent market with functioning market mechanisms, the provider who can best serve demand individually has the greatest chance of success.

It is therefore more important than ever for companies to focus on customer benefit. They will have to answer for themselves the question of how to serve the needs and expectations of end customers. The greater the contribution of each partner to creating a solution, the easier it is for the company in question to stand out from the competition. One example is a roller bearing manufacturer who not only has the direct requirements of the plant manufacturer in mind, but also those of the end customer, to whom additional services can be offered in the form of evaluating bearing status data using a cloud solution. This enables the end customer to operate the plant more efficiently. This in-depth understanding of end customer needs also makes the roller bearing manufacturer more attractive to its direct customers than its competitors.

Companies can pursue different strategies in this regard. It can be promising both to contribute specific skills to an overall solution and to offer various individual solutions. There is moreover a need to define the role that one's own company wishes to play in the value network. In essence, this capability is about constantly reviewing one's own skills and adapting them to new circumstances if necessary.

5.4 Technology & Data

The "Technology & Data" structural area deals with the information systems that enable smart service business. Information systems are sociotechnical systems in which people interact with and via information and communication technologies in order to provide, process, store and transfer information according to economic criteria.[14] The configuration of information systems and data and information handling are crucial to making correct decisions and offering successful services. Advancing digitalisation is enabling manufacturing companies to make decisions based on data analysis or to develop new services. Nevertheless, product, operational and environmental data and information based on them are not currently used in many manufacturing companies. For this to change, companies need not only an adequate technological basis with coordinated IT systems but also effective data management, in particular in terms of data management and data governance (see figure 10).

5.4.1 Technology

Technical capabilities are an essential basis for using data efficiently and effectively. This requires real-time capable access to data, and data processing and provision infrastructure. While

12 | See Schuh/Kampker 2011, p. 504f.

13 | See also Benölken/Greipel 1990.

14 | This STUDY draws a distinction between information systems and IT systems. IT systems are individual application systems (e.g. ERP system), while information systems should be taken to mean socio-technical systems according to the above definition.

real-time capable data access is enabled by the connectivity of the product (see "Connectivity" principle), the IT infrastructure needs a central platform which connects existing IT systems to one another and with further resources, for instance data sources. Many manufacturing companies do not use data and information to make decisions, as data from different departments is not centrally administered. Companies are therefore faced with the challenging target of integrating the various systems in the value chain. Solutions are to be found in a strong information system architecture and system interoperability.

Information system architecture

An agile company's information system architecture will have a central platform connecting existing IT systems together and to other resources. Nothing should be duplicated in different IT systems, but rather just one master information system should be created containing all the data (*Single Source of Truth*). A central platform of this type for information system connectivity requires standardised interfaces, comprehensive IT security and data quality which is in line with requirements.

Interoperability

Smart services are often based on data from various sources. If smart services are to be able to create customer benefits, systems need to adapt to changing parameters, if possible in real time. Achieving this demands rapid data processing which means that IT infrastructure interoperability is a key requirement: uniform standards have to be created if heterogeneous IT systems are to interact efficiently. Open source solutions are also an option for companies.[15] What is key is for companies to

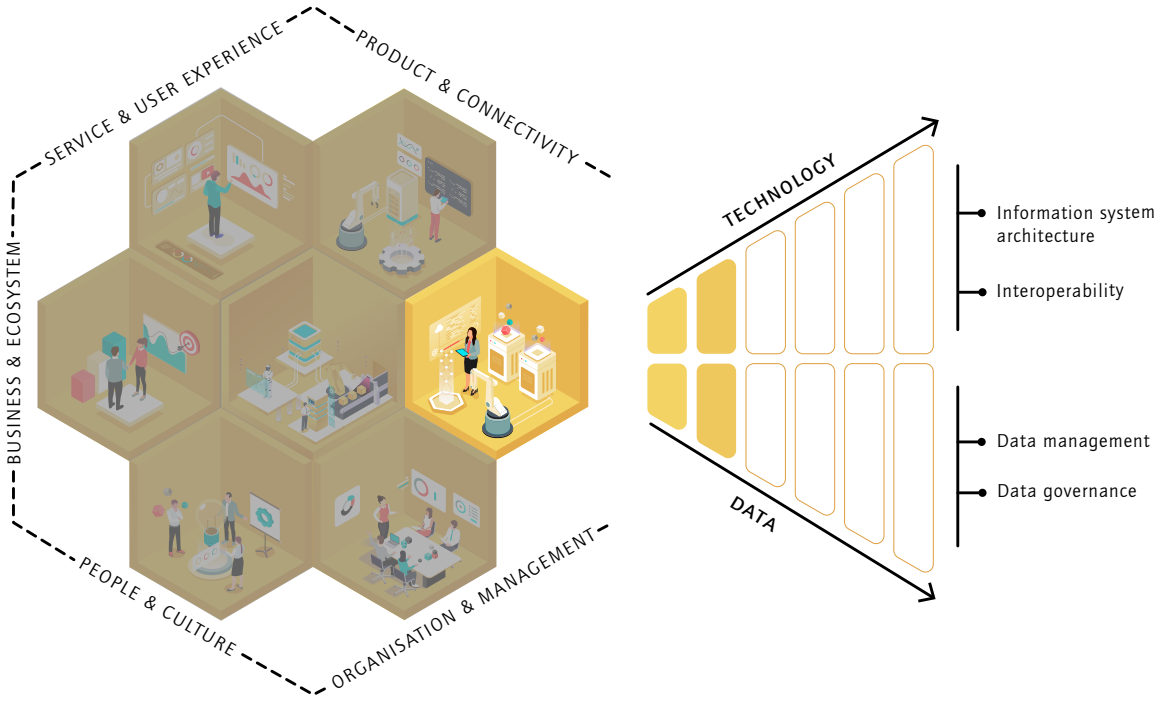


Figure 10: Principles and selected capabilities of the "Technology & Data" structural area (source: own presentation)

15 | See also Forschungsbeirat/acatech 2022.

implement a flexible IT infrastructure, which allows them now and in the future to respond rapidly to changing parameters. Companies should not only have in-house processes in their sights, but also the entire ecosystem and value network consisting of data from customers, partners and competitors.

5.4.2 Data

Data are the most valuable resource when it comes to delivering marketable smart services. How skilfully a company handles data is often the decisive factor in whether it is actually capable of offering smart services. The data that are collected are frequently not further processed into information or services because they are not available to staff members. Consequently, when looking at the "Data" principle, the central question is how acquired data are processed and made available so that they can be used as a basis for developing services.

Data management
Effective data management ensures that all types of data, be they product, environmental, customer or ecosystem data, can be put to the best possible use in supporting internal and external processes. For a smart service business, management of the data retrieved from smart products is particularly necessary (see "Product & Connectivity" structural area).

This requires a data management system which, where possible, allows real-time capable data updating and prepares data in such a way as to remove any barriers to analysis and further processing. User-friendly provision is important when it comes both to using data and to (further) developing services on the basis of these data. Only when members of staff understand what information and conclusions can be derived from the data can they develop innovative products, services and business models on the basis of these data.

Data Governance
The increasing prevalence of social media and collaboration software means new rules are needed regarding confidentiality and access restrictions for internal and in particular external communication. This sometimes leads to conflicts of interest: on the one hand the broadest possible data corpus is important if decisions are to be based on it, while on the other hand these data may under certain circumstances be protected as part of the company's intellectual property, in which case they must not be used outside the company boundaries and value networks.

Standards such as the international IEC 62443 series offer IT security concepts for networks and production engineering systems. Daily dealings with IT systems and sometimes sensitive data require all staff members to be aware of IT security. Staff members should therefore be acquainted with issues such as data theft and (inadvertent) information leaks.

5.5 Organisation & Management

The smart service transformation requires a degree of maturity in the technologies described above. Use of these and the establishment of a smart service business requires the definition of strategic objectives and resultant initiatives and of specific organisational processes and communication paths. In practice, however, companies often cling to their existing organisational structures, processes and strategic goals. This frequently proves to be an obstacle, since it cannot be reconciled with the high degree of interdisciplinary working needed to establish smart services. To be successful and set the appropriate course, companies must consequently rethink their organisational structure and management focus. These considerations fall under the "Organisation & Management" structural area (see figure11).

5.5.1 Organisation

Key to the "Organisation" principle is the adaptation of processes and organisational forms which provide the structure for cooperation within a company. Companies often underestimate the amount of effort required in the way of interdisciplinary exchange between specialist domains to bring successful smart services to market. Corporate practice therefore frequently lacks sufficient coordination, for instance during the development process or service provision, which impedes the development of smart services. To eliminate these obstacles, companies must re-orient both their existing organisational structure and their workflow organisation to suit smart service business.

Workflow organisation (processes)
The rollout of smart services requires adjustments to workflow organisation, i.e. to company-wide process organisation. Central to this is coordination of business and IT processes so that smart services can be successfully developed and marketed. For instance, the IT department should promptly inform key account managers in the sales department about problems arising in smart service provision, so that they can contact the

affected customers directly. For this, processes need to be as comprehensively automated and digitalised as possible.

To tailor smart services to customer requirements, it is also essential for the internal development process to be as agile as possible and to include all relevant internal stakeholders, i.e. generally staff members from IT, business functions and sales. This requires an enabling organisational structure which includes the relevant staff members and equips them with the appropriate skills.

Organisational structure

What form of organisational structure is suited to a company offering smart services depends to a very great extent on that company's culture and the progress it has made towards transformation. Some companies, for example, may initially find it useful to research, test and implement smart services in just one area, in isolation from other organisational units. This method is known as sandboxing. On the other hand, in an organisation whose portfolio is (to be) dominated by smart services and which thus are (or should be) already at a higher maturity level, a different approach is advisable. Such companies might assemble interdisciplinary cross-divisional teams in a matrix organisation, for example.

In addition to smart service business becoming embedded in the organisation, another factor which is crucial to success is how a company deals with the new and changed requirements which servitisation brings with it. For example, staff members in the sales department will no longer merely have to provide

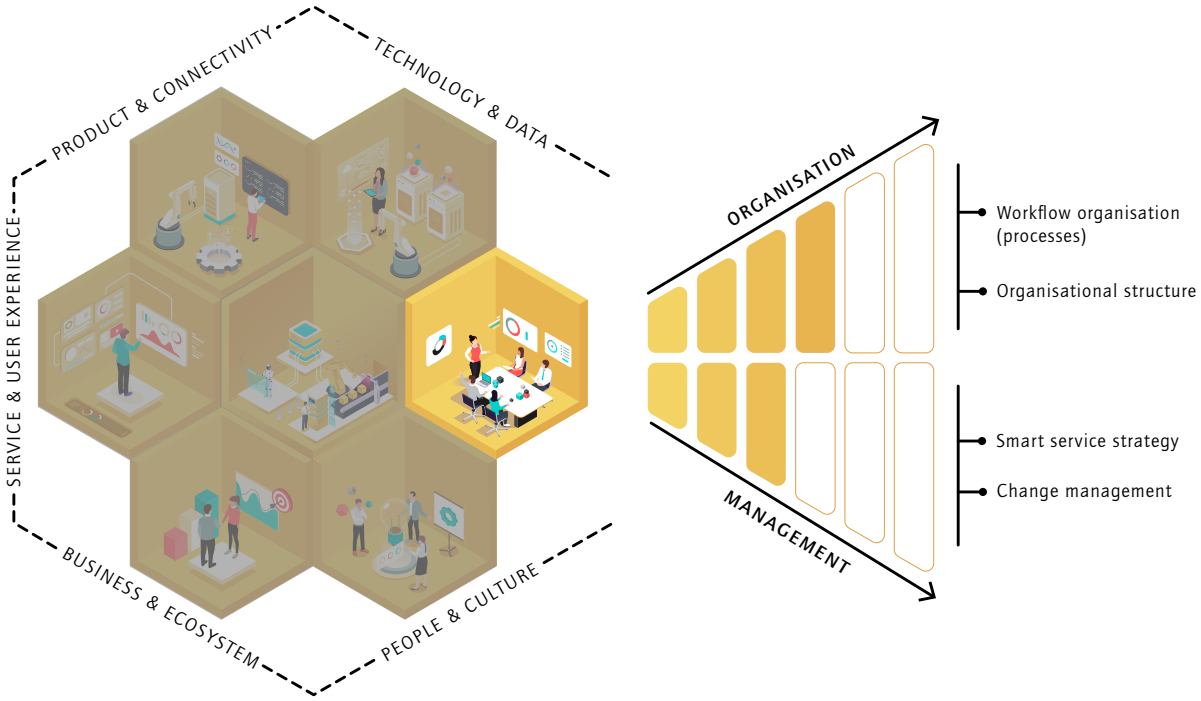


Figure 11: Principles and selected capabilities of the "People & Culture" structural area (source: own presentation)

one-off services when selling products but will instead be in constant contact with their customers, and the company's organisational structure needs to be adapted to take this change into account. Also essential is for IT units to view themselves as internal service providers for business units. This simplifies internal cooperation and the efficient digital development of smart services.

5.5.2 Management

Transformation and digitalisation projects often fail under real-world conditions because of a lack of support from top management. To make sure this does not happen, change processes need to be embedded in a strategic commitment to smart service business and set in motion at all hierarchical levels. In addition, if transformation is to be successfully initiated and the smart service business embedded and consolidated in everyday business activity, agile management needs to be implemented across the organisation on a permanent basis. A clear-cut smart service strategy and well-defined change management are crucial here.

Smart service strategy
In addition to a commitment at top management level, smart service business has to be comprehensively integrated into company strategy. A smart service strategy will ideally lead to changes in organisation, business model, portfolio focus, the understanding of skills and all the other organisational aspects discussed here. In the best case, a smart service strategy is based on an exhaustive analysis of technology, the market and competitors. A smart service strategy defines the transformational vision and the measures needed at corporate planning level to achieve this vision and is thus crucial for evaluating the smart service transformation across the maturity model presented in this STUDY.

Change management
Specific, strategy-based changes relating to the organisation as a whole are needed to put the smart service transformation into operation. These must be well communicated and prepared to allow full staff member involvement and participation. All stakeholders must be provided with transparent, structured information about changes to organisation, tasks and processes. At the same time, management must clarify how these changes will contribute to the smart service transformation. This structured approach ensures that change can be embraced proactively by staff members.

5.6 People & Culture

Innovative companies benefit from employees who take an agile approach to work. Agility is an important factor when it comes to successful transformation processes. Other factors are a good corporate culture, an innovative spirit and service-focused staff. To gain a better understanding of the prevailing culture, companies need to consider for themselves what staff behaviours are required to effect the transformation to a smart service business (Culture) and what capabilities these staff need to display (People). This is the basis for identifying and introducing appropriate technologies (see figure 12). One example worthy of mention could be digital assistance systems. Simply rolling these out is of no benefit to a company, but if employees trust such a system and rely on its suggestions they can make an effective contribution.

5.6.1 People

For smart services to be offered, staff members must have knowledge, capabilities and skills in the areas of Industrie 4.0, digitalisation and service focus. The surrounding business environment, in the form of partners, customers, competitors and the labour market, also needs to know or be made aware of the fact that a company has these capabilities at its fingertips. This makes it easier to recruit personnel and acquire partners within the smart service ecosystem. These aspects are looked at in the context of the "People" principle.

Skills management:
capabilities for smart service companies
Staff working in digital service companies have more than ever to be in a position to access, acquire and process data and information, so as to be able to make a well-founded decision. Consequently, staff need to have a basic knowledge of the value of data and the information derived from data in short-, medium- and long-term decision-making. In addition, personnel working in a smart service company should have a shared understanding of what Industrie 4.0 means and how this concept is to be implemented in their organisation.

Since information systems and communication technologies play an increasingly important role, companies need to build up integrated, interdisciplinary IT skills. The aim should be for all staff to gain a basic understanding of the applications and processes in the various company departments and to understand that digital capabilities are needed in all areas of exper-

tise. This put companies in a position to leverage synergies through interdisciplinary cooperation.

Digital service affinity

Smart services, i.e. data-based services which complement the purely physical products offered and enable the range of services to be flexibly matched to specific, individual client wishes or expectations, require manufacturing companies to comprehensively strengthen their service focus. When it comes to staff, this entails not only developing the necessary skills but also changing the way the staff see themselves and how they interpret and decode their tasks in the company. A "customer first" mindset is crucial, as is an explicit focus on emphasising and marketing the (added) value or increased benefits resulting from the provision of a smart service compared with the offer of purely physical products.

As with companies which exclusively sell digital solutions, at the point of sale a particular focus must be laid on creating and nurturing customer loyalty and on onboarding the user into the smart service. These skills and focus have either to be built up by a company itself, for instance by further staff training, or acquired externally on the labour market. This increase in digital service affinity can at the same time be a significant building block for the development of new, customer-oriented smart services and is therefore an important criterion for corporate success.

5.6.2 Culture

A good corporate culture enables and motivates staff members. The "Culture" principle encompasses the value system within the company and thus describes the "soft" factors in-

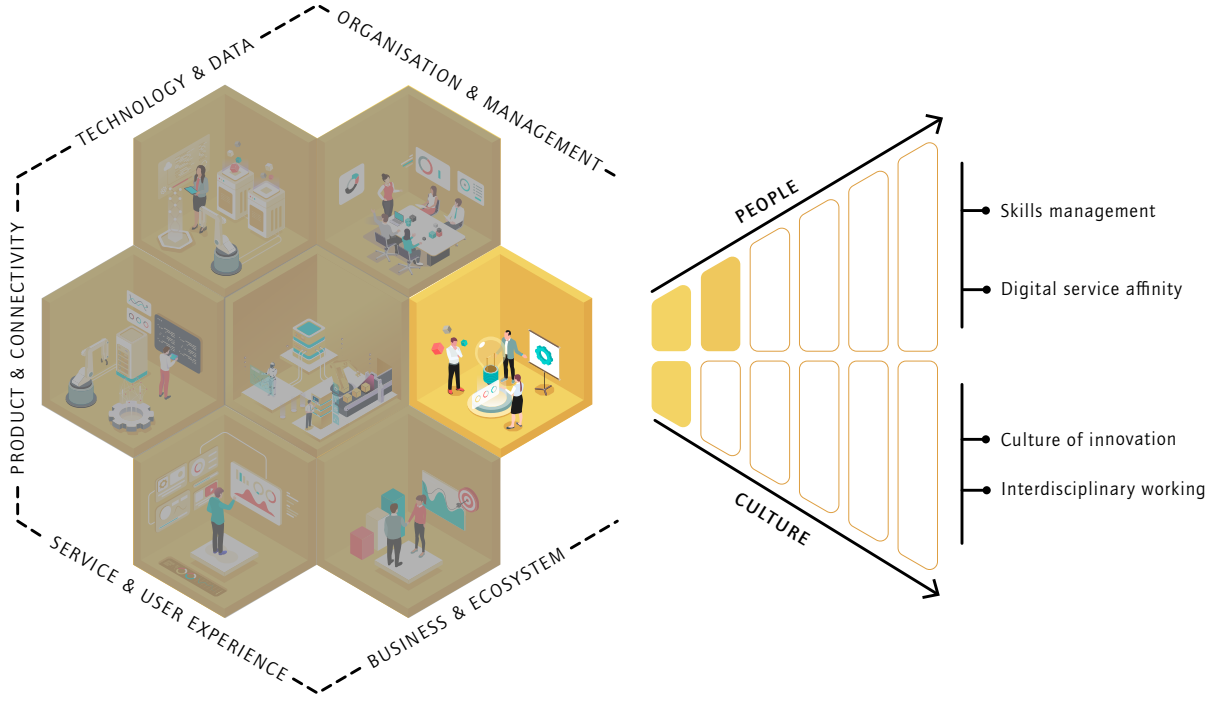


Figure 12: Principles and selected capabilities of the "People & Culture" structural area (source: own presentation)

volved in working together. It should be considered in close association with "Organisation", which describes the "harder" aspects of working together, such as processes and organisational structure. The "Management" principle, which deals with strategy and leadership, also has to be brought into line with the corporate culture. These principles are closely interlinked.

The degree of agility of a company is dependent on the behaviour of its employees. Experience over the last 30 years has shown that the success of *lean management* is dependent on whether a company as a whole undergoes a change in culture and whether the individual staff members are ready and able to embrace this change. The same is true of the transformation to learning, agile companies. Introducing digital technologies and comprehensively servitising manufacturing companies will not lead to the desired agility unless attention is also paid to the in-company culture. This agility is needed, however, as employees will find themselves in a very different landscape. An ever greater emphasis is being placed on information and communication technologies in products and processes. Steadily increasing automation of many process steps means that employees will have to add greater value in their work. In the long run, technical competence alone will no longer suffice. To deal with the dynamics of executing change, companies need staff who can work and think across disciplines, are committed to ongoing learning and can take autonomous decisions. To encourage these characteristics, companies must create a culture which is open to innovation and values interdisciplinary working.

Culture of innovation

Employees of smart service companies need to be willing to review and adjust their working practices continuously. This situation only arises in companies where a well-developed culture of innovation prevails. The ideal is where all staff members are eager to shape change.

Readiness to embark on change and adopt a culture of innovation does not only mean that staff members go along with and implement change. It means, too, that they observe their immediate environment and the corporate environment in a way which is open to recognising opportunities and need for change and initiate measures to bring about that change. An openness to change breeds agility. Openness to innovation also requires tolerance of mistakes and a culture of trial and error. Establishing this in a manufacturing company where the prevailing attitude is often one of perfectionism is a major challenge.

Interdisciplinary working

The development of smart services requires interdisciplinary working at every stage of the value creation process. Interdisciplinary working encompasses not just the functional composition of teams but also a culture of mutual learning, which has to be shared by all employees. This is closely linked with a culture of innovation. Interdisciplinary working means bringing together staff members with different functions and skills and enabling them to optimally mesh together service, product, business model and IT expertise. For this to be achieved as efficiently and effectively as possible, employees from different disciplines have to find a common basis for understanding. Various methodological approaches can be adopted in this regard.

Technical experts have skills which are essential if the best possible solution is to be provided to customers. Companies should value and promote such expertise. Where experts from different disciplines work productively together, markedly better results can be achieved, especially at interfaces. This is a central factor in success, especially in smart service projects, since the processes involved in such projects typically have a large number of interfaces.

6 Applying the acatech Maturity Index Smart Services

The acatech Maturity Index Smart Services was primarily developed for manufacturing companies, in particular for manufacturers of physical producer goods such as components, machinery or systems. Using the maturity model, it is intended to enable companies to assess where they are currently positioned regarding the transformation to being smart service providers. It also describes the value creation potential companies can unlock using smart services and provides a focus for definition. Companies can then build on this using the roadmap it provides as a basis for analysing and developing their actual and target maturity levels. This roadmap describes the processes and functions which are central to the integrated development of smart services.

6.1 Principles for application

The acatech Maturity Index Smart Services defines three transformation phases which build on one another (see figure 13). The first phase determines the current maturity level and the capabilities present within a company, which it does by interviewing relevant stakeholders within the company and looking at existing processes. The second phase determines the target and compares it with the actual status. The basis for this is the previously determined maturity level and the individual company's corporate strategy. Depending on the desired target situation, which is either specified by the company or jointly agreed, this actual/target comparison provides insights into what capabilities the company needs to build up and what potential can be leveraged. The third phase develops the roadmap, which lays out measures and projects for achieving the previously defined targets. These are located on a timeline with schedule bars on the smart service roadmap.

Phase 1: Determining current maturity level in terms of smart service transformation

The capabilities available in the respective companies (see section 5) determine the smart service maturity level. A company's maturity level is ascertained by asking one question per capability. The capabilities are used to investigate in terms of solutions and user focus the various processes and functional areas which are relevant to maturity level. On the basis of an evaluation scheme, the answers are then weighted according to the maturity levels achieved for the specific capabilities. This results in a mean value for the maturity level of the principle in question. The values for the respective principles are aggre-

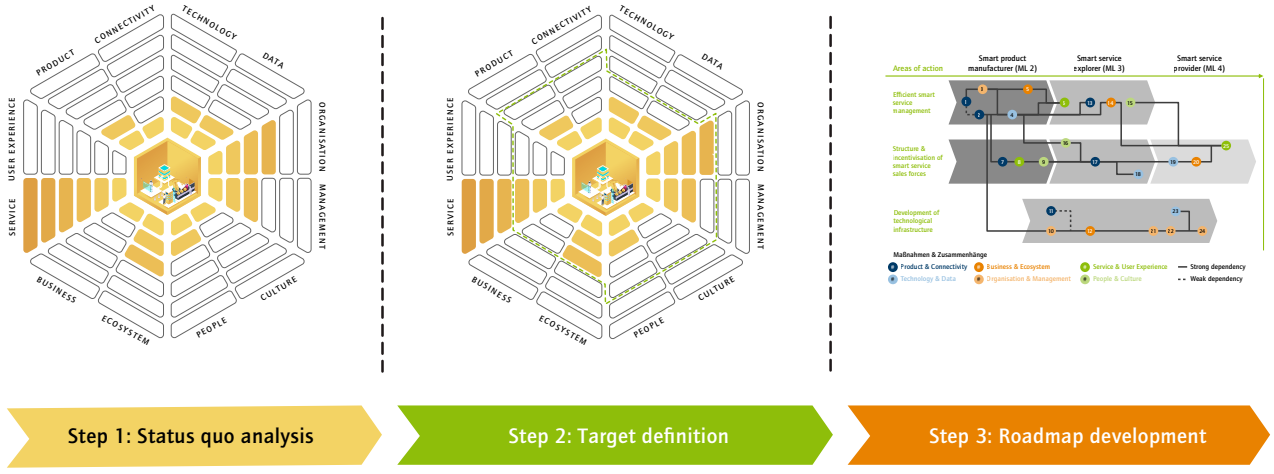


Figure 13: Phases of applying the acatech Maturity Index Smart Services (source: own presentation)

gated and produce the maturity level for the corresponding structural area. The overall assessment is only carried out by trained personnel, via the digital smart service assessment platform. This platform also makes it possible to collect information in a structured format and evaluate it semi-automatically (for instance for benchmarking reports).

Figure 14 shows an example of how a capability is evaluated using a question. The question relates to the "Product & Connectivity" structural area and investigates the capability of the physical product to acquire data for the development of smart services. The defined response options allow companies to clearly determine the maturity level of this capability. The means of all the capabilities associated with the "Product" principle determine this maturity level.

The detailed assessment and evaluation take place within the company. The analysis phase starts by creating a uniform understanding of smart services among the stakeholders in the process. This takes the form of a presentation, which is followed by a workshop which offers space for exchange between the stakeholders. This is then followed by a factory visit or a look at the products and services. The impressions and information gained from this by the stakeholders can be used in subsequent steps of the analysis phase. Interviews are then carried out systematically with the staff members responsible for processes and products and the results are consolidated on the smart service platform. The interviews allow an interactive exchange on the smart service transformation in terms of the capabilities in the maturity model. They also allow the assessors to pick up further information, proposals for improvement and aspirations from company representatives regarding their organisation's smart service transformation. The analysis phase concludes with a joint workshop with all the relevant company stakeholders, at which the objectives relating to establishing an organisation's smart service business are dis-

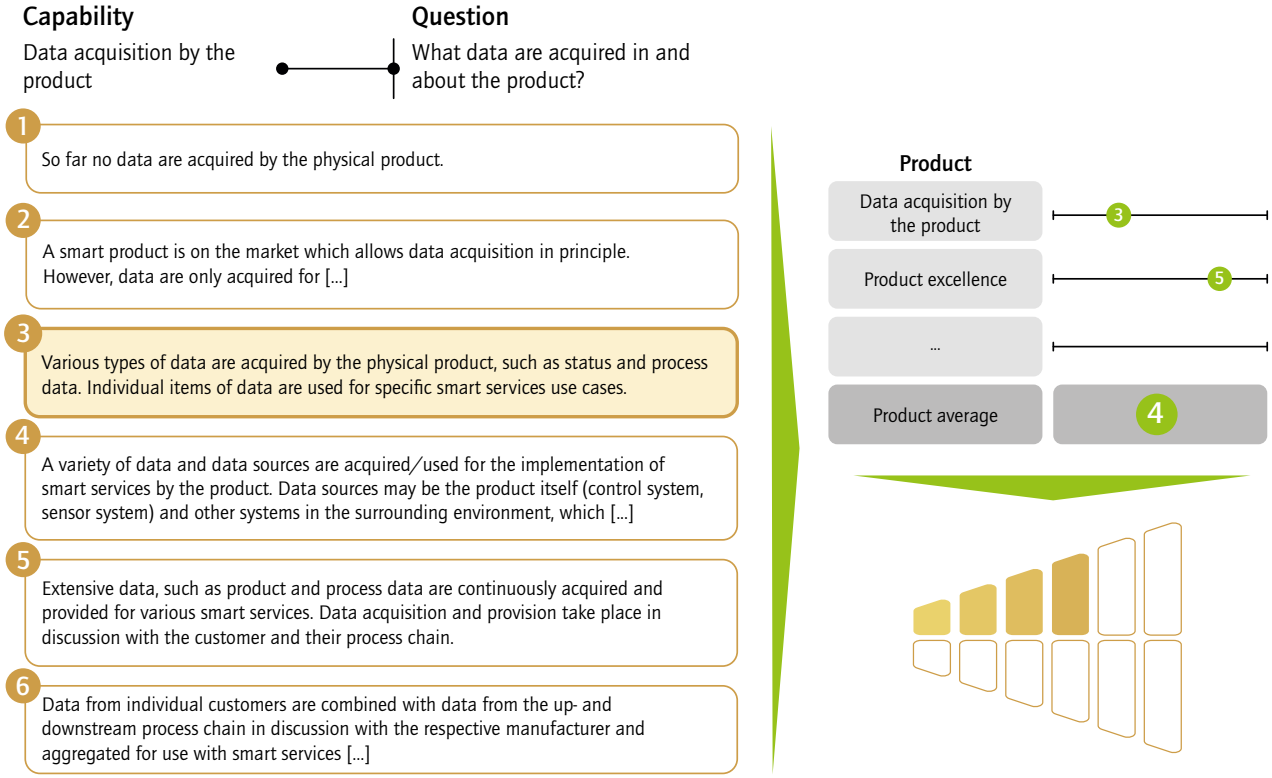


Figure 14: Assessment of a capability example for the maturity model (source: own presentation)

cussed and fleshed out. The maturity level evaluation at the customer site terminates with an interim presentation by the assessors, during which the provisional actual status of the smart service transformation is visualised in terms of the structural areas and presented to the participants.

Phase 2: Target determination and actual/target comparison
One or more smart services can be evaluated on the basis of the capability assessment. The assessment of individual services is aggregated to produce the smart service maturity level of the site or company. The current situation is represented as the smart service transformation hexagon, which shows the extent of maturity per structural area and visualises potential for development.

Taking this as basis, the company determines the target of the smart service transformation jointly with the assessors. This target may vary slightly between structural areas, but the discrepancies should not be too great. This is because overall progress can stall if individual divisions or structural areas have already moved well ahead on the transformation journey while capabilities in other structural areas are at a low level of maturity. If this happens, companies may be hindered from fully exploiting their potential.

To deal with such discrepancies as quickly as possible, they need to be quickly identified. That is why phase 2 involves an actual/target comparison. The purpose of the actual/target comparison is to move development of the six structural areas onwards in a consistent, uniform way. The automatically generated actual/target comparison in the smart service transformation hexagon produces coloured labels which indicate gaps in the respective structural areas in terms of the smart service transformation targets (see figure 15).

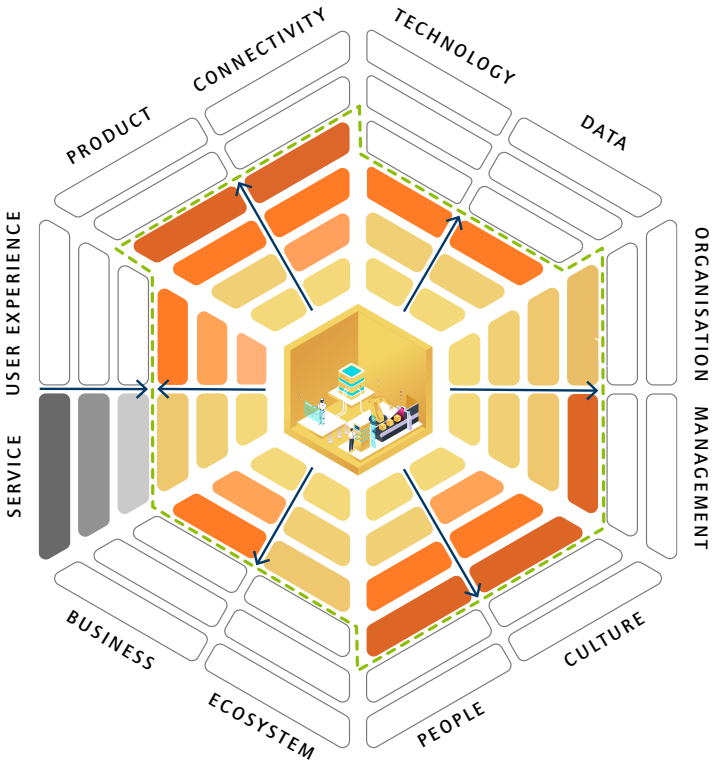


Figure 15: Gap analysis of a company's actual and target maturity levels (source: own presentation)

To exploit their full smart service business potential, companies should aim in a first step to leverage capabilities within structural areas at similar maturity levels, so as to enjoy the benefits of the highest maturity level. First of all, therefore, the divisions with the lowest maturity level need to be improved. In the next development step, starting from the maturity levels that they have already improved, companies should concentrate on achieving targets in the various structural areas. Here too, they should take care to proceed uniformly.

Phase 3: Roadmap development with finalisation of actions to be taken

In the third phase, specific measures for reinforcing a company's smart service transformation are developed, on the basis of the company's vision and the level of maturity of its assessed smart services. The platform assists in identifying any actions that need to be taken and in generating measures which are in each case directly associated with the capabilities requiring improvement. The platform has various tools available for structuring the formulated measures. It is possible, for example, to filter all the capabilities by maturity level or to prioritise those capabilities which are particularly in need of improvement. Alternative measures which have been discussed with regard to improving the various capabilities can also be saved. On the basis of these, in dialogue with the company, the assessors can formulate measures which are then located on the company's customised smart service roadmap (see figure 16 for a schematic representation of a roadmap).

The roadmap does not give a precise time sequence in which the measures need to be implemented, since this is dependent on company resources. The acatech Maturity Index Smart Services does, however, propose a time and implementation horizon. In addition, companies are given an overview of what ma-

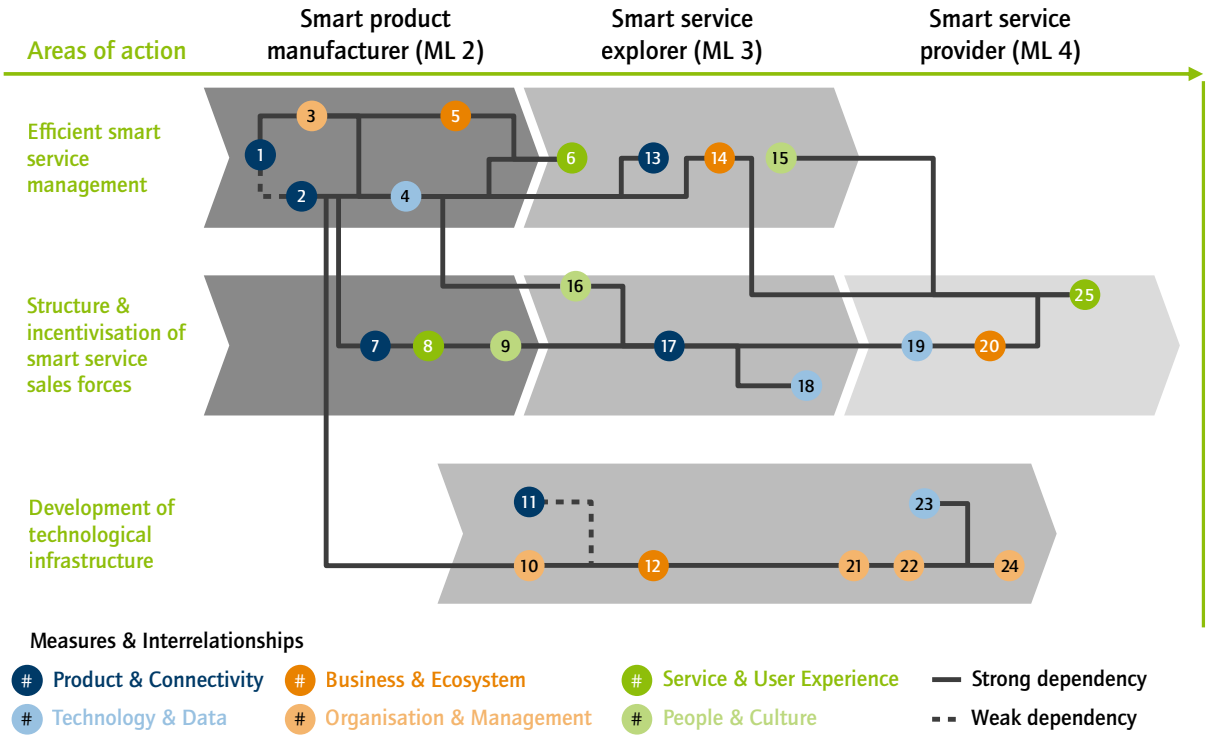


Figure 16: Roadmap for structured transformation across structural areas (source: own presentation)

turity level they will reach if an individual measure or package of measures is successfully implemented. This process step also shows companies how the measures on the roadmap are interdependent. An illustration is also given of the extent to which measures build on one another and why the strategically correct first step is to attain a uniform maturity level.

6.2 Applying the acatech Maturity Index Smart Services – an example

Three companies took part in the validation of the acatech Maturity Index Smart Services in spring 2023 – GEA Westfalia Separator Group GmbH, Kraft Maschinenbau GmbH and Kuntze Instruments GmbH. The validation process involved testing whether the toolkit we have developed is relevant and applicable under real-world conditions. Comments and insights from this practical testing have subsequently been used by the project team to make adjustments to the design and procedure.

The practical tests took place on company sites with members of the project team present. The tests focused on areas which are particularly relevant to the development of smart services, for instance sales, service, product management and data analytics as well as selected IoT-capable products. The project team set up workshops in the companies with the process and product managers for these areas and informed them of the reasons behind the assessments and their purpose and function. Particular stress was laid on the maturity model and the individual process steps. The on-site assessment included an analysis of the use of the companies' existing smart services in a real-life environment (in some instances using dummy data), interviews with those responsible for processes and a trial of two different approaches.

The first approach is very comprehensive: customised questionnaires were created for the interviews, which were tailored to the expertise of those interviewed. The questionnaires were stored on the smart service platform and linked to the corresponding key themes (for instance individual principles or even capabilities). This allowed the project team members to be flexible in carrying out the assessment and to individually schedule the many interviews. Such an approach is suitable in particular for large companies, where smart service business typically covers all functional units, making exchange with various teams essential for a solidly based assessment.

The second approach is less flexible but quicker. It is particularly suitable for smaller companies where only a small number of people have responsibility for smart service business. In this case, the project team organised a one-day workshop, at which department-specific interviews were carried out for each structural area. Experts took part in the interviews relating to their respective specialist areas. All the interviews were carried out by at least two members of the project team. During the interviews, one person led the discussion while the other recorded information and filled in the questionnaire. After the interviews, the results were consolidated on the platform, additional information was documented and an initial report issued.

In a third step, at the end of the on-site phase and irrespective of which approach had been adopted for the second step, the project team presented the results of the consultation on the current situation, i.e. the appraisal of the actual degree of smart service transformation (phase 1), and discussed this with the participants. The presentation included the results for the individual departments and an overview of the assessed smart services in the structural areas. These results were discussed with the management team in the workshop for defining smart service transformation goals (phase 2) in order to set short- and medium-term objectives and decide on what maturity level can realistically be achieved.

The interviews and workshops were followed by a working phase outside the company, in which the project team consolidated the insights obtained and derived policy recommendations (phase 3). For this, the team again used the smart service platform to identify capabilities which are at a low maturity level. Based on the insights which the project team had acquired during the on-site phase, essential areas of action were identified and specific measures located on a roadmap. The results were presented to the interviewees in a final presentation and discussed.

The outcome is clear: by offering an orderly framework for structured assessments, interviews and maturity level evaluation, our smart service assessment, supported by the digital assessment platform, is a suitable method for providing serious, evidence-based assistance to mechanical and plant engineering manufacturing companies as they undergo a smart service transformation.

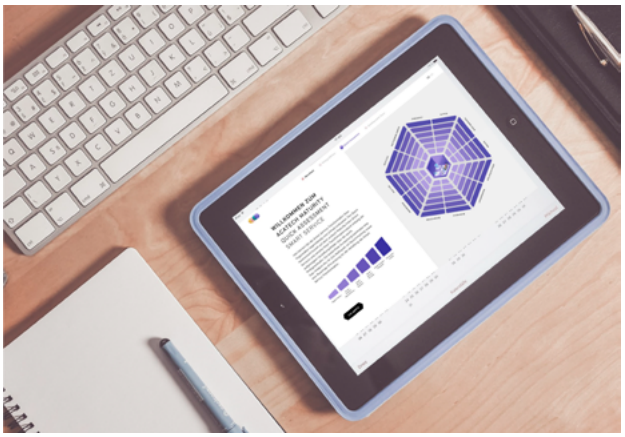
6.3 The acatech Maturity Hub Smart Services – maturity model-based tools

To make further information available about the projects and tools included within the acatech Maturity Index Smart Services, the Maturity Hub Smart Services[16] was set up as a centralised, freely accessible website. The Hub is designed as a one-stop support shop for companies wishing to take a proactive approach to their smart service transformation which is scientifically based, practical, comprehensive and intuitive. The Hub is made up of four parts: a brief description of the acatech Maturity Index Smart Services, access to the Quick Assessment tool, information about the project team and a "development journey".

The latter offers an insight into the smart service transformation vision, the challenges involved in implementing that vision, the background to the methodological approach adopted as well as into the development of the maturity model and information on the relationship between the maturity model and the associated assessments. The interactive representation of the acatech Maturity Index Smart Services explains the model's overall structure and rationale for application. The website also introduces the project team that users can contact if they are interested in an in-depth assessment. Finally, the website offers interested parties an opportunity to keep up with publications and up-to-date information and to be notified of events on the smart services theme via a regular newsfeed.

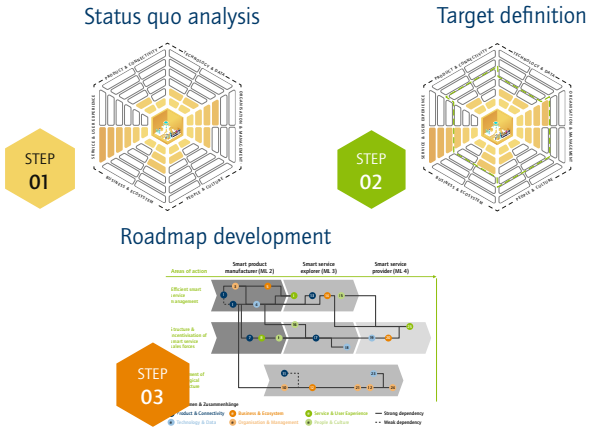
The acatech Maturity Hub Smart Services also offers access to the acatech Maturity Quick Assessment[17]. This Quick Assessment allows interested companies to obtain a free, guided assessment of their individual smart service maturity level. In addition to the procedure described in section 6.1 (concept) and in section 6.2 (example of application) for an assisted in-depth assessment carried out by the project team on company sites and a customised evaluation and comprehensive programme of measures, the Quick Assessment provides companies with an initial appraisal of their current situation in terms of the transformation to offering smart services. The Quick Assessment uses a software-based web tool and its concept is based on the acatech Maturity Index Smart Services. It provides a simplified way of locating a company's transformation status within the six maturity levels across the indicated structural areas. The free evaluation includes a gap analysis between actual and target maturity levels, benchmarking and the development of a simple roadmap for strengthening smart service transformation. The results of the Quick Assessment provide initial insights, which can then be looked at in more detail in the context of the assisted in-depth assessment.

Quick Assessment



Independent self-location of the current situation

In-depth Assessment



Customised evaluation & list of measures

Figure 17: Quick Assessment and assisted assessment of smart service transformation level (source: own presentation)

16 | Available from: https://acatechmaturityhub-smartservices.de.
17 | ibid.

7 Conclusion and Outlook

As early as 2014 and 2015, the Federal government's "*Smart Service Welt*" future project set out their vision for (manufacturing) companies to use intelligent products connected to the internet to create smart services within digital ecosystems.[18] The basis for this is the idea and concept of digital factories under the Industrie 4.0 umbrella. Even all those years ago, the value creation potential associated with servitising services to create new customer experiences had been recognised.

For smart services to be able to provide a meaningful complement to physical products and flexibly fulfil individual customers' specific desires, a company needs to undergo a comprehensive and complex transformation. It is not sufficient merely to make slight modifications to physical products. Instead, they must be rethought and redeveloped as software systems. These new products form the basis for new intelligent services which the companies can offer their customers. This transformation process often disrupts traditional thought patterns, processes and structures, which is not always easy for companies. However, without it, business models with a smart service focus cannot be designed and implemented.

The acatech Maturity Index Smart Services provides manufacturing companies with a framework for tackling this complex, multi-faceted task, delivering comprehensive guidance for successful implementation of this transformation. The acatech Maturity Index Smart Services maturity model describes six maturity levels and six structural areas with specific principles and capabilities on which change needs to focus. The maturity model is regularly updated and takes account of technical and economic developments and potentially changing parameters.

A freely accessible website, the acatech Hub Smart Services, provides interested company representatives with information about the structure, rationale and areas of application of the Maturity Index Smart Services. In addition, a free Quick Assessment is available on the website, which companies can use to obtain an initial overview of where their company stands in terms of smart service transformation.

The Maturity Assessment Smart Services available via the Hub evaluates transformation progress in detail and delivers a more in-depth understanding with regard to service- or site-specific or even company-wide adoption of smart service business. The assessment is based on an actual/target comparison, which compares the current situation with the desired target maturity level. This comparison reveals the need for action, which is broken down into specific measures in the form of an individual roadmap. These insights can also be used for benchmarking, with companies comparing how they are doing with organisations in their peer group. A specially developed *Code of Conduct*, which provides a structure for the detailed assessment and for planning the necessary actions, offers assessors additional methodological support.

The services based on the acatech Maturity Index Smart Services are designed to offer long-term guidance to manufacturing companies and provide direction for the actions and measures they take. This is important because the time in which we are living sees companies exposed to many rapid changes, triggered for instance by the spread of new technologies such as innovative artificial intelligence solutions or by changes in values such as human-centredness. Further challenges arise from environmental, economic and social sustainability requirements, or changed political parameters such as Russia's war of aggression against Ukraine and the resultant economic consequences in the form of supply bottlenecks etc..

In contrast to the B2C sector, in which US and Chinese platform companies known as "hyperscalers" now have an almost unassailable lead, European and in particular German manufacturing companies have a good chance to defend and strengthen their good market position by linking digital and physical offerings to create smart services. An in-depth understanding of physical components and products is a significant competitive advantage that German and European providers have over international competitors, who will find it difficult to catch up. Manufacturing companies will not be able to improve their market position without regarding data not just as a component of certain products or services but rather as the central focus, allowing them to align themselves consistently with customer needs.[19]

Companies which configure their smart service business to focus on environmental considerations and so contribute to the

18 | See Arbeitskreis Smart Service Welt/acatech 2014, 2015
19 | See Riemensperger/Falk 2022.

Circular Economy are in a particularly good position to stand out from the crowd. Providing smart service-based customer solutions with far-reaching upgrade and re-assembly possibilities will create enormous future potential for profitability with low materials usage. Vehicles are a good case in point: in the context of an intelligent mobility solution, these will be made available to customers as a smart service with significant added value (e.g. in terms of reliability/availability), in the long-term allowing upgrades at low cost. This example shows that adding digital service excellence to product know-how in smart services creates market opportunities, and the acatech Maturity Index Smart Services helps in leveraging these.

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Smart services – an effective triad of product, service and customer-centric value proposition – offer opportunities for manufacturing-focused companies to achieve differentiation and seize new market opportunities. As the still limited uptake of smart services shows, manufacturing companies face complex challenges in combining the building blocks of product, service and value proposition into sustainable and competitive smart services, developing and implementing successful business models and adapting organisationally to a smart service ethos. Even the big players will struggle to go it alone, but Germany as a centre for innovation also depends on its hidden champions – small and medium-sized companies.

This acatech STUDY - Maturity Index Smart Services presents a maturity model with six structural areas for transforming manufacturing-focused companies into smart service providers. In this model, progress towards establishing a smart service business is measured along six maturity levels, so enabling a successful transformation both practically and on a firm evidence basis. Using a specially developed toolkit, companies can be guided through the adoption of a smart service business.

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