Industrial Marketing Management 102 (2022) 546–563

Contents lists available at ScienceDirect

Industrial Marketing Management

journal homepage: www.elsevier.com/locate/indmarman

A contextual account of digital servitization through autonomous solutions: Aligning a digital servitization process and a maritime service ecosystem transformation to autonomous shipping

Hannu Makkonen [a,*], Sini Nordberg-Davies [b], Jouni Saarni [b], Tuomas Huikkola [a]

[a] University of Vaasa, Finland
[b] Turku School of Economics, University of Turku, Finland

ARTICLE INFO

Keywords:
Servitization and digital servitization
Autonomous solutions and autonomous shipping
Service ecosystem
Digital innovation and digitalization

ABSTRACT

This study focuses on digital servitization (DS) through autonomous solutions by building on a service ecosystems perspective. The rise of autonomous solutions exemplifies the ongoing digitalization and societal transformation and therefore integrative theoretical perspectives are needed to complement the dominant focal actor perspective in extant DS research. The study presents a longitudinal case of a solution provider's DS process to demonstrate how transformation towards autonomous shipping was driven in the maritime sector. An empirically enriched framework communicates DS process as aligned changes in value propositions, resource configurations and institutional arrangements within the service ecosystem. The study offers academic contributions and practical implications on managing DS through autonomous solutions as a strategic reorientation of a firm in the multi-level context of service ecosystem transformation.

1. Introduction

Digitalization as a megatrend transforms the logics of society and companies (Legner et al., 2017; Pekkarinen et al., 2020), providing increasing opportunities for manufacturing companies in Industry 4.0, Artificial Intelligence (AI), Cloud Computing, and Autonomous Solutions (Lusch & Nambisan, 2015). This shapes manufacturers' business strategies (Porter & Heppelmann, 2015, 2017) and models (Frank, Mendes, Ayala, & Ghezzi, 2019), associated organizational capabilities (Linde, Sjödin, Parida, & Wincent, 2021), routines (Huikkola, Kohtamäki, Rabetino, Makkonen, & Holtkamp, 2021) and practices (Sjödin, Parida, Kohtamäki, & Wincent, 2020). Along this megatrend, digitalization and servitization have converged (Kohtamäki, Parida, Oghazi, Gebauer, & Baines, 2019) into digital servitization (DS) research that posits digital features from an assistive to a primary role in servitization (Raddats, Kowalkowski, Benedettini, Burton, & Gebauer, 2019). This emerging stream of literature has produced understanding on data-driven offerings and business models (Paschou, Rapaccini, Adrodegari, & Saccani, 2020) embodying increasingly extensive configurations such as product-service-software systems (PSSS) (Hsuan, Jovanovic, & Clemente, 2021; Jovanovic, Sjödin, & Parida, 2021), smart technology (Grubic & Jennions, 2018; Porter & Heppelmann, 2015), smart factory (Sjödin, Parida, Leksell, & Petrovic, 2018), smart supply chains (Meindl, Ayala, Mendonça, & Frank, 2021), and autonomous solutions (Parida, Sjödin, & Reim, 2019). The last includes unmanned machines or vehicles bundling hardware, software, and services in a way that does not necessitate human intervention (SAE International, 2016).

Autonomous solutions represent the most complex and interlinked end of digital technologies that widely connect the focal servitization company to its business and societal contexts (Iansiti & Lakhani, 2014; Parida et al., 2019; Paschou et al., 2020; Porter & Heppelmann, 2015, 2017; Reim, Sjödin, & Parida, 2018; Saidani et al., 2020). Autonomous solutions thus challenge DS research to progress towards a systems-oriented perspective (Porter & Heppelmann, 2015). Recent DS research has taken steps in extending the focus from the transformation of a firm towards a focus on ecosystem-level reconfiguration (see Bustinza, Opazo-Basaez, & Tarba, 2021; Huikkola, Rabetino, Kohtamäki, & Gebauer, 2020). Particularly, Sklyar, Kowalkowski, Tronvoll, and Sörhammar (2019) apply the service ecosystems perspective for capturing variant institutional arrangements and versatile actors that contextualize the focal servitizing company and its servitization process. Similarly, Polova and Thomas (2020) approach servitization as a collaborative innovation project involving an extensive set of external partners, while Kohtamäki et al. (2019) focus on business models in

* Corresponding author at: University of Vaasa, School of Marketing and Communication, PO Box 700 FIN-65101 Vaasa, Finland.
E-mail address: hannu.makkonen@uwasa.fi (H. Makkonen).

https://doi.org/10.1016/j.indmarman.2022.02.013
Received 15 September 2020; Received in revised form 13 October 2021; Accepted 25 February 2022
Available online 11 March 2022

connected ecosystems. Despite these recent contributions involving a systems perspective, the majority of extant DS research focuses on alterations of a focal company's single technologies and business models, as the literature review by Paschou et al. (2020) demonstrates. Thus, our understanding is still on its outset regarding complex DS processes exemplified in autonomous solutions that feature changes in focal company business logic as well as systems-level emergence of novel business areas, convergence of industries and transformation of ecosystems (see Paschou et al., 2020).

This study adds to the rising DS research stream (Paschou et al., 2020; Sklyar et al., 2019) by drawing from the service ecosystems perspective (Akaka, Vargo, & Schau, 2015; Sklyar et al., 2019; Vargo & Lusch, 2011; Vargo & Lusch, 2016) and studying a firm's actions within the ongoing service ecosystem transformation towards autonomous solutions. Respectively, the focal study is set to answer the following research questions: 1) what are the key elements of DS through autonomous solutions in the context of service ecosystem transformation, and 2) how can these elements be managed to facilitate DS?

The study presents a longitudinal study (2015–2018) of Rolls-Royce Marine's (RRM) journey towards autonomous solutions (Gu, Goez, Guajardo, & Wallace, 2020; Rolls-Royce, 2016; Strønen, 2014) and how RRM was able to push forward the transformation in the predominant shipping ecosystem. The study offers two interlinked contributions by providing an analysis of a nascent area of autonomous solutions in DS research (see Parida et al., 2019), and by providing a contextual account of DS that joins the previous efforts to pave the way towards systemic approaches (Kohtamäki et al., 2019; Polova & Thomas, 2020; Sklyar et al., 2019). The study puts forward an empirically enriched framework and extensive set of propositions that link the DS process to service ecosystem transformation. The framework provides guidance for further academic research and a basis for managers to identify the key elements and arenas to influence when driving DS through autonomous solutions.

2. Theoretical background

2.1. Digital servitization through autonomous solutions

DS synthesizes a focal company's digital and service transformation (Kohtamäki, Parida, Patel, & Gebauer, 2020) by focusing on the use of digital tools for transforming a company's business logic from product to service centric (Sklyar et al., 2019; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). Servitization considers mostly intra-firm transformation (Ulaga & Reinartz, 2011) and its implications to customer relationships (Töytäri et al., 2018; Tuli, Kohli, & Bharadwaj, 2007), whereas digital transformation features a more connected process linking the focal company with the digitalization megatrend and service ecosystem transformation (Appio, Frattini, Petruzzelli, & Neirotti, 2021; Nambisan, Lyytinen, Majchrzak, & Song, 2017). Thus, "digital" adds an extra layer in the servitization strategy and changes the focus from an intra-firm, customer-oriented process to a systemic process of aligning network members' activities to enable the development of systemic offerings across boundaries (see Frank et al., 2019; Kamalaldin, Linde, Sjödin, & Parida, 2020; Vendrell-Herrero et al., 2017).

Manufacturers' movement towards autonomous solutions is part of firms' continuous morphing and repositioning within the ecosystem (Huikkola et al., 2020; Kohtamäki et al., 2019). Autonomous solutions build on advancements in new digitally enabled technologies such as automation, Internet of Things (IoT), augmented reality (AR), machine learning, and artificial intelligence (AI) featuring interlinked digital systems and innovations (see Iansiti & Lakhani, 2014; Nambisan et al., 2017; Porter & Heppelmann, 2015, 2017). Autonomous solutions thus represent the most advanced end of DS by featuring scalable and interconnected sets of smart solutions connected to other systems without human intervention (Thomson, Kamalaldin, & Sjödin, 2021), e.g. self-driving cars or unmanned vessels. We build on previous definitions of autonomous solutions (Darling, 2011; Thomson et al., 2021) and adapt Thomson et al., 2021: 15) description of the highest maturity level of autonomous solutions: *"Operating independently of human control and capable of 'learning', optimizing operations and handling mission deviations"*. Thus, autonomous solutions (AS) go beyond traditional (remote) services, as they contain technical ability to make decisions independently and learn based on accumulated data to optimize operations across firm boundaries. Technologically, fully autonomous solutions require deployment of AI and sensor-based technologies to learn and optimize e.g., production cycles (in traditional DS strategies, control typically remains with humans). On the ecosystem level, autonomous solutions typically need wide-range collaborations across industries and ecosystems (in traditional DS strategies, focus is on interlinked value chains within the ecosystem; see Huikkola et al., 2020). Considering business models, autonomous solutions utilize outcome-based contracting and redefined risk/profit sharing (see Keränen, Terho, & Saurama, 2021) (in traditional DS strategies, business models focus on monetizing through products and services such as spare parts and projects; see Thomson et al., 2021). To capture these systemic characteristics of AS and their implications on the DS process the following section draws on the service ecosystems perspective to synthesize a multi-level theoretical framework for the study.

2.2. A service ecosystems framework for digital servitization through autonomous solutions

The service ecosystem concept rooted in the service-dominant logic (Vargo & Lusch, 2004, 2016) and service science (Maglio & Spohrer, 2008) refers to "relatively self-contained, self-adjusting systems of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange" (Vargo & Lusch, 2011, 15). Given this rather flexible definition, a service ecosystems perspective can accommodate a broad set of technological, business, and societal actors, their resource integration and shaping institutional arrangements into a common framework of multi-level and -actor value co-creation (Vargo & Akaka, 2012; Akaka, Vargo & Lusch, 2013; Vargo & Lusch, 2016).

The conceptual framework in Fig. 1 applies a service ecosystems approach on depicting DS and service ecosystem transformation as synchronized phenomena. The former highlights a focal company's transformation towards a digital service-oriented business logic (Sklyar et al., 2019; Vendrell-Herrero et al., 2017), while the latter focuses on the systemic change required in the transformation towards autonomous solutions (see Appio et al., 2021). Along the service ecosystems perspective, the framework interprets both DS and service ecosystem transformation as multi-level value co-creation that is operationalized as the realignment of value propositions, resource configurations, and institutional arrangements on the 1) actor, 2) stakeholder system and 3) society levels encompassing the service ecosystem (Chandler & Vargo, 2011; Frow et al., 2014; Vargo & Lusch, 2011, 2016).

The actor level in the framework refers to organizations who pursue or facilitate DS strategies. Service ecosystem transformation to autonomous solutions requires many types of actors that form a stakeholder system (see Frow et al., 2014) i) to implement requirements deriving from the society level (top-down) and ii) to engage in actions that introduce new solutions that accumulate on the society level (bottom-up). DS aligns value propositions on all of the levels. On the actor level, value propositions refer to how key actors develop their customer value propositions (Payne, Frow, & Eggert, 2017) to support their position and role with regard to the transition and convergence of industries and increasingly complex and connected offerings. On the stakeholder system level, value propositions are reciprocal (Frow et al., 2014) in terms of value sought and value offered and created by the actors concerning other actors in the stakeholder system (Chandler & Lusch, 2015; Storbacka & Nenonen, 2011). On the society level, the value proposition relates to improved functioning of the society and related wellbeing and quality of life for citizens (Corvellec & Hultman, 2014; Patala et al.,

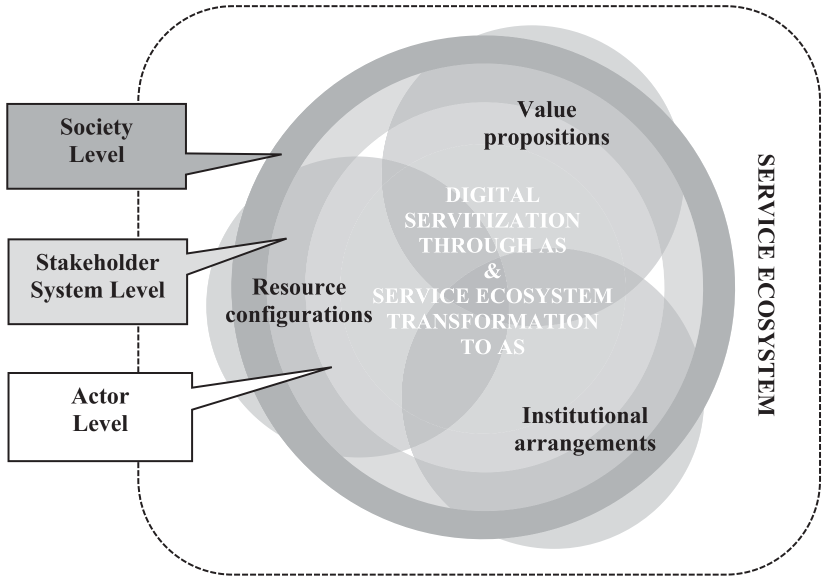

Fig. 1. Conceptual framework.

2016).

Value propositions are backboned by actor resources (Kowalkowski, Witell, & Gustafsson, 2013; Payne et al., 2017) and realized through resource integration creating stakeholder system resource configurations and links to society-level resource constellations (Vargo & Lusch, 2011, 2016). Thus, DS through autonomous solutions requires changes in resources on all levels of context. The usefulness of resources, that is, tentative resources "becoming" usable resources, depends largely on the institutional context in which they are embedded (Chandler & Lusch, 2015; Vargo & Akaka, 2012). Thus, the link between value propositions and resource integration is mediated by institutional arrangements (Vargo & Lusch, 2016).

Institutional arrangements encompass interrelated sets of institutions, i.e. "the rules of the game" that shape resource integration (Edvardsson, Kleinaltenkamp, Tronvoll, McHugh, & Windahl, 2014; Vargo & Lusch, 2016). On the actor level, institutional arrangements refer to company business models (To, Chau, & Kan, 2020), i.e. the architecture for creating customer value propositions and using resources (Coreynen, Matthyssens, & Van Bockhaven, 2017; Vendrell-Herrero et al., 2017). DS literature has identified different business model (BM) archetypes (and their configurations) for solution providers such as 1) product provider, 2) industrializer, 3) integrated solution provider, 4) platform operator, and 5) performance provider (Kohtamäki et al., 2019). On the stakeholder system level, institutional arrangements refer to stakeholder system policies and principles regarding industries and business fields (Makkonen & Olkkonen, 2017). On the society level, institutional arrangements refer to economic, political, legal and cultural norms and values (Möller, Nenonen, & Storbacka, 2020).

The framework defines DS through autonomous solutions as managerial actions that aim at facilitating the alignment of resource configurations, value propositions, and institutional arrangements to support both the firm-centric DS process as well as systems level service ecosystem transformation. Considering DS as actions of alignment is in line with previous research (Bustinza, Gomes, Vendrell-Herrero, & Tarba, 2018) that largely focuses on realignment of organizational structure, business model and resource base (Coreynen et al., 2017; Tronvoll, Sklyar, Sörhammar, & Kowalkowski, 2020; Vendrell-Herrero et al., 2017). However, Fig. 1 elaborates the notion of realignment on the levels of society, stakeholder system and actors. Thus, the focal DS actor is not only aligning its intra-organizational elements but aims at facilitating the service ecosystem transformation by managing the alignment within and between multiple levels that requires balancing between competition and collaboration, i.e. coopetition (Kamalaldin et al., 2020; Paschou et al., 2020; Vendrell-Herrero et al., 2017). The following section reports how the framework is applied to structure the empirical study.

3. Research methods

3.1. Research design and case selection

This study features a longitudinal qualitative single case research strategy to obtain in-depth understanding of how a solution provider, Rolls-Royce Marine (RRM), embarked on transforming its business model and develop solutions for autonomous shipping with the explicit intention to also "redefine shipping" (Rolls-Royce, 2016). The repositioning included the establishment of a new business unit carrying out some of the first global scale initiatives to demonstrate an autonomous ship concept. This attracted wide attention and sparked further worldwide developments that have increasingly been gaining momentum to make commercial autonomous shipping a reality.

We purposefully selected (see Eisenhardt, 2021) RRM for deeper analysis, as it 1) was one of the leading actors pushing for autonomous shipping solutions, 2) has been the first firm in its sector to establish an autonomous shipping vision, and 3) has taken strategic initiative to initiate discussion regarding autonomy not only in the shipping industry, but also advance discussion more broadly in the traditional manufacturing industry (Eisenhardt, 2021). Qualitative methods are particularly useful when the studied phenomenon is complex and research is at its early stages (Eisenhardt, 2021; Piekkari, Plakoyiannaki, & Welch, 2010). Hence, as autonomous solutions is a new research topic, the single case study method is suitable for understanding this nascent phenomenon. Since the studied firm is publicly traded, financial statements, such as interim and annual reports, stock market data, press releases, investor speeches, and public presentations, were largely available for research purposes.

The study is set between 2015 and 2018, during which some of the research team worked closely together with RRM. During these four years, we collaborated with RRM in two different industry-academia research projects regarding autonomous shipping, built ongoing rapport by meeting regularly as part of the research projects and outside of them, and organized a joint business model innovation course at the university. We were able to observe RRM bring together universities, ship designers, OEMs, system suppliers, classification society, shipyards, and ship owners to understand different economic, social, legal, regulatory, and technological factors needed to make autonomous shipping a reality. We gained access to connect with these various actors and built deep research relationships through research consortia to understand their actions and the formation of the autonomous shipping stakeholder system. During this timeframe, autonomous ships came into the limelight and gained remarkable traction, also outside the shipping industry. This sparked the formation of consecutive research projects and cooperative networks, which widened the scope of research to the development of autonomous solutions in global logistics. However, in 2018 the story of Rolls-Royce Marine ended when the group's commercial marine business unit was acquired by Norwegian OEM Kongsberg. Yet its legacy in autonomous shipping lives on today at Kongsberg and the budding startup scene involving former RRM employees.

3.2. Data collection

The empirical research implements multiple data sources to achieve data triangulation (Beverland & Lindgreen, 2010; Woodside & Wilson, 2003) (see Appendix 1). Along the idea of exploratory, theory developing case research strategy (see George & Bennett, 2004; Halinen & Törnroos, 2005), the conceptual framework offered concrete themes for interviews (see Appendix 2 – Interview guide) and the possibility for inductive insights to emerge from the data. Semi-structured interviews were used to obtain data from experts involved in the two industry-academia projects as well as from marine industry representatives outside of the consortia. The interviewees representing technology suppliers were chosen so that at least one interviewee with relevant experience and expertise covered each technology area of autonomous shipping. Our deep understanding of the research context facilitated us to identify potential interviewees. We also utilized the snowball technique by asking informants and other actors in the research process to name potential interviewees (Miles & Huberman, 1994). Presentation materials received from seminar organizers were used to support and complement the written field notes. Secondary data was collected through internet searches, newsletters and magazines of both marine industry and mainstream media. Additionally, we sought automotive and aviation industry articles at the beginning of the project in 2015–2016 for broader pre-understanding of autonomous solutions development when autonomous shipping had not yet attracted wider media interest.

3.3. Data analysis

To allow for flexibility in data collection, oscillation between data collection and data analysis took place in this study (Dubois & Gadde, 2002). At the end of the data gathering phase, we used the NVivo 12 program to facilitate data coding. We conducted theory-driven thematic analysis (Braun & Clarke, 2006) by disaggregating segments of data following a provisional set of codes derived from the conceptual framework. Whilst remaining open for possible inductive themes to emerge from the data during the iterative analysis process, none appeared that would have challenged the preconceived conceptual framework (Miles & Huberman, 1994). This yielded the sets of first-order categories that were synthesized into nine second-order integrative themes regarding the contextual levels and each theoretical dimension. Integrative themes represent aligned change processes that pave the way for autonomous shipping (Appendix 3 summarizes the final coding structure).

After the coding, a narrative approach to analyzing data was utilized in reporting the findings in an integrated and multi-dimensional manner (Floersch, Longhofer, Kranke, & Townsend, 2010). Floersch et al. (2010) attribute the narrative approach with the ability to add a plot to describing how the themes recognized in the thematic analysis come together to create understanding through a cohesive story. The narrative approach was particularly useful in portraying a credible interpretation of the dynamics of autonomous solutions emerging on multiple levels (Makkonen, Aarikka-Stenroos, & Olkkonen, 2012). Furthermore, the narrative approach enriched the initial conceptual framework with empirical insights regarding the alignment of value propositions, resource configurations and institutional arrangements in the multi-level context of a service ecosystem to constitute the empirically enriched framework (see Gebhardt, Carpenter, & Sherry Jr., 2006) in Fig. 3. Particularly, we found that in the systemic context of autonomous solutions, the focus of the DS actor is not only on its focal DS process, but also on how to 1) facilitate the initiation of parallel DS processes, and for this purpose how to engage complementors to the focal DS process and facilitate the drivers to set up and run the parallel DS processes, 2) facilitate the emergence of the stakeholder system and how to link it with other stakeholder systems for knowledge exchange and learning, and 3) stimulate and tackle the societies-level opportunities. These findings regarding DS management represent the empirical enrichments that we accommodate to the empirically enriched framework depicted in Fig. 3. Appendix 4 describes the trustworthiness of this study by using the criteria according to Lincoln and Guba (1985). Next, the results of our analysis are reported through a case narrative of how events unfolded, followed by analysis of aligned changes that took place on multiple levels of context to accelerate the service ecosystem transformation towards autonomous shipping.

4. Findings

4.1. Rolling out maritime autonomous solutions

Fig. 2 displays the key events of autonomous shipping development on a timeline regarding the actor, stakeholder system and society levels. We divide our analysis in three phases: 1) Screening (2012–2014), 2) Establishing opportunity (2015–2016), and 3) Concretizing (2017–2018).

Phase 1: Screening for technological opportunities 2012–2014

The launch of the EU-funded MUNIN project in 2012 placed the vision of the autonomous ship concept firmly on the maritime industry's agenda. We refer the MUNIN Project as A1 and list it first in the list of secondary sources (Appendix 5) followed by a series of timely and opportune events in the following years, referred to as A2-A81. The MUNIN project was a culmination for a process started in the 1990s, during which the dominant position of shipyards as integrators in the maritime sector has gradually shifted, as equipment suppliers have begun to propose their offerings directly to shipping companies. Many have progressively broadened their offering base, e.g. Wärtsilä by making complementary acquisitions in 2012 (A2) and 2014 (A3). This is associated with a growing interest towards the utilization of improved ICT in shipping, e.g. in the form of predictive maintenance solutions (Rabetino, Kohtamäki, Lehtonen, & Kostama, 2015) and energy optimization software development, e.g. by ABB and smaller companies Eniram and Marorka. Similarly, Rolls-Royce Marine held a strong but dependent position in the offshore oil and gas market, which resulted in gradually weakening sales and profits after the 2008 financial crisis and continuously low oil prices. It was rumoured that Rolls-Royce considered acquiring Wärtsilä (A4), which implies that RRM was searching for a broader market base. Indeed, top management of the group had set an ambitious goal:

> *"[…] Rolls-Royce needs to be raised onto the Boston Consulting Group's list of 50 most innovative companies in the world. They've [top management] seen that it's not enough for us to do things in the short-term, but we need to be in the same league with these companies that genuinely look to the future".*
>
> (R&D manager 1)

Thus, RRM proceeded to establish a Blue Ocean Team with a goal *"to look into new markets in 5 to 10 to 15 years, looking beyond the traditional*

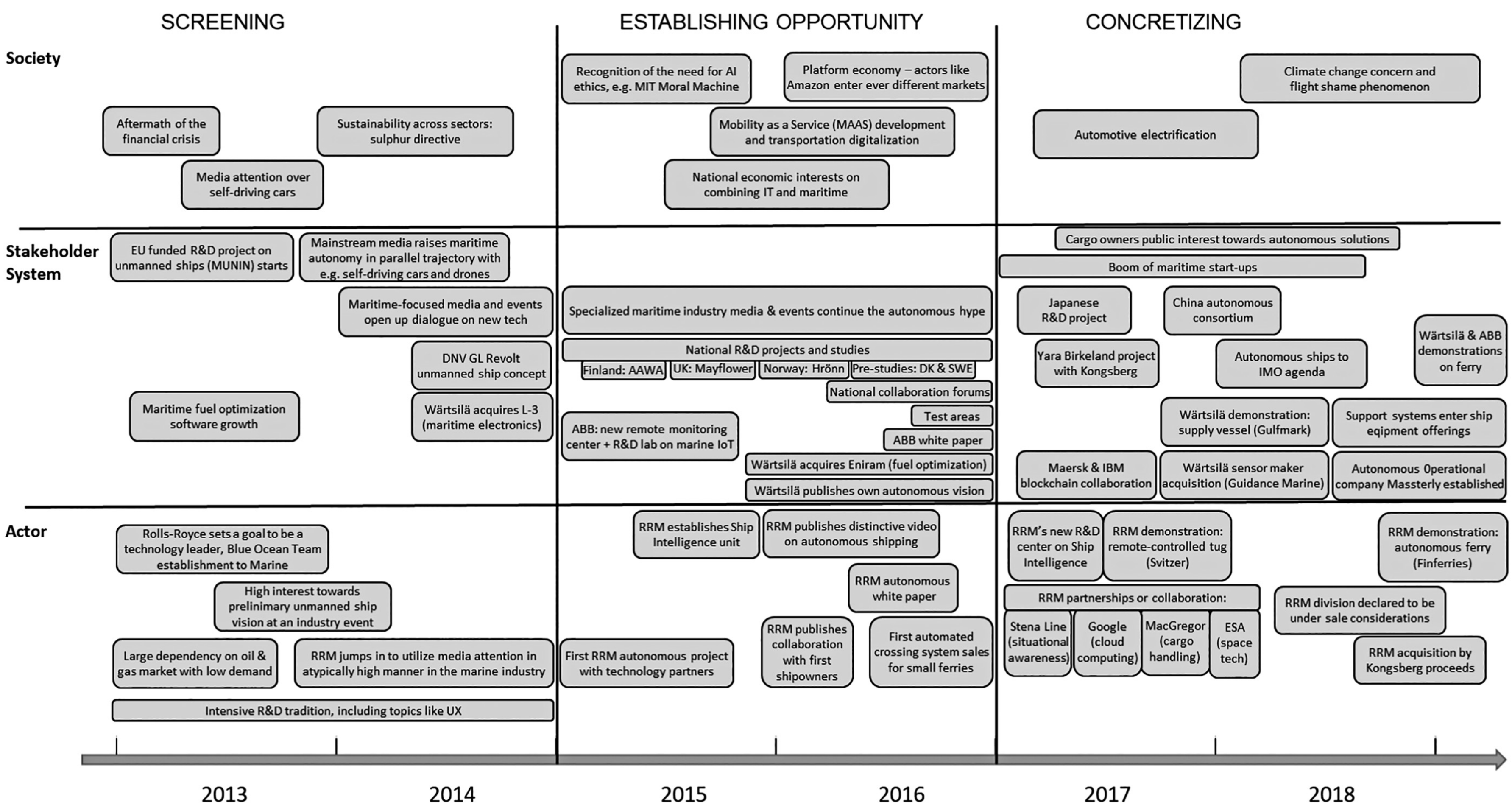

Fig. 2. Timeline of key events in autonomous shipping development.

R&D timeline of our company" (A5). Beyond this, RRM followed the group's R&D orientation, and engaged in UXUS, a research project on user experience and service design, which generated some ideas that were later integrated into the company's autonomous ship vision (A6).

In mid-2013, the RRM team had prepared 7 future technology visions for an industry event, out of which the idea of autonomous operations received the most media attention (R&D Manager 1). Simultaneously, the development of self-driving cars had gained increased attention in the general public (A7), while Amazon was testing delivery drones (A8). Within months from the industry event, mainstream media had attached Rolls-Royce as an iconic British brand to the rapidly rising autonomous technology trend (A9). The possibility of autonomous operations was a fresh perspective to the maritime sector, often considered a laggard in technology adoption:

> *"I've welcomed the new initiative, because I think the shipping industry as a whole is in a big transition phase in the sense that digitally exporting data, efficiently and remotely, is something extremely revolutionary for our industry".* (Ship management representative).

As media attention expanded globally, the pros and cons of autonomous ships were brought into light (see A10-A14). In dozens of articles and interviews, RRM fed new ideas, details, and counter-arguments to concerns, thus gradually broadening the original ship-level vision to a set of autonomous systems and operational practices.

Phase 2: Establishing the opportunity 2015–2016

After some months of mainstream media attention in 2014, the maritime-specific media proceeded to engage in more detailed discussion on the topic (e.g. A15, A16, A17). Meanwhile, self-driving car development brought up ever more complicated topics, such as the ethics of AI (A18).

In mid-2015, RRM gathered a consortium to specify its vision of autonomous shipping, and launched the AAWA-project with the purpose of "Redefining shipping" (A19). Simultaneously, RRM reacted to the weak market situation with job cuts and restructuring (A20), and a Ship Intelligence solutions unit was formed, which gradually started to grow with business goals on "smart ship" systems:

> *"When we talk about this autonomous ships theme, it demands a different kind of competence layer on top of the current organization. But it's not just that, when we see that in the future what guys are doing in the ship intelligence side is going to need a lot of investment. When we move towards the internet of seas, smart systems solutions etc. that this [autonomous ships] is maybe a part of."* (R&D manager 1).

Similarly, e.g. ABB invested in an integrated operations center and R&D lab on marine IoT (A21; A22), and Wärtsilä acquired Eniram, an optimization software firm (A23). New R&D projects emerged as nationally-forming consortia, e.g. in the UK (A24) and Norway (A25).

To stay ahead, RRM capitalized on its media attention and published more detailed views, e.g. a video in spring 2016 visualizing an autonomous ship maintenance scenario (A26), and an industry white paper (A27). This accelerated maritime automation further, as competitors ABB (A28) and Wärtsilä (A29) published their own autonomous shipping visions soon after. Simultaneously, RRM published its collaboration with shipowners as potential customers of autonomous solutions to gather credibility for maritime automation (A30). It also utilized national Finnish profession-related networks for collaborating with various stakeholders to advance its autonomous shipping vision.

> *"I'm coordinating these autonomous ship ecosystem* issues *with the maritime cluster, and on Friday we had a meeting with Wärtsilä and others to sketch how to move forward in this project, running through the ministries etc. I don't think anyone's ever put their cards on the table like this. […] It's pretty rare that competing tech firms would commit to the same industry strategy straight up, just like that.*" (R&D manager 2).

National support emerged as automation received wider attention in countries with long maritime technology traditions. This was visible through e.g. funding of previously mentioned R&D projects, anticipatory regulative work for automation in Finland (A31), and pre-studies in Sweden and Denmark (A32, A33). During 2016, structured public communities began to form around maritime automation, e.g. the first autonomous shipping conference in the Netherlands (A34), followed by national collaborative development forums set up in Norway (A35) and Finland (A36). Both countries also authorized national autonomous ship test areas to illustrate concrete progress (A37, A38).

Phase 3: Concretizing autonomous solutions 2017–2018

In phase 3, the previously shaped visions were turned into solutions in the companies' offerings through technology demonstrations and first supportive products to the market. More detailed issues and connections to other domains emerged as the autonomous ship vision became established in the industry.

Alongside autonomous ships, the industry also pondered other digitalization opportunities. Already before 2017, disruptive impacts of Amazon's supply chain actions (A39) to logistics services caused speculation. Traditionally, the maritime sector has not seen many start-ups, but digitalization spurred new entrants, e.g. digital freight marketplaces (A40) and utilizations of blockchain technology (A41). In spring 2017, giants Maersk and IBM entered into collaboration to explore blockchain technology, which led to the formation of the Tradelens consortium (A42, A43). In another twist, a cargo owner, the mining company BHP (A44), expressed interest to utilize autonomous solutions managed by digital marketplaces.

In early 2017, RRM announced the establishment of a new R&D unit in Finland fully focused on ship intelligence offerings (A45). Numerous IT professionals were hired, which differed from its machinery-driven past (A46). Opportunely, after the fall of Nokia mobile phones, a high number of experienced software experts were available in Finland, introducing new skills and views to the maritime sector.

> *"This old, classic sector is suddenly at this turning point, and the know-how that used to be in another industry, the mobile industry, is suddenly available to be utilized. It's lucky that we now have this kind of opportunity here […]"* (R&D manager 3).

RRM also continued to form complementary partnerships with e.g. cargo handling (A47), cloud computing (A48), and satellite-based communications and positioning (A49) companies. Meanwhile, Wärtsilä acquired a sensor company as a key technological capability (A50). Progressively, the demand side expressed public interest to explore autonomous solutions. Already developed in late 2016, RRM succeeded to sell its automated crossing systems for small ferries (A51), and collaboration involving sensor systems with larger ferries was announced (A52). Other actors joined newly launched consortia in Norway (A53), Japan (A54), and China (A55).

Autonomous shipping took a central step forward when technology demonstrations appeared between mid-2017 to late 2018. The industry witnessed a remote-controlled tug (A56), a supply vessel (A57), and ferries (A58, A59, A60). Major system providers were quick to demonstrate proof-of-concepts, after which it was evident that technological ground for autonomous ships existed. During 2018, assisting automation systems (A61) and situational awareness systems (A62) were added to sales offerings.

Another milestone was the launch of a process to include autonomous ships into the agenda of the International Maritime Organization (IMO) in mid-2017 (A63), which was the first step in a long journey of international maritime regulation modifications (see Ringbom, 2019). To push for regulative change, national autonomous ship forums in nine countries took the role and carried out international collaboration (A63).

In the midst of a race in advanced ship equipment development, Rolls-Royce was announced to consider the sale of its commercial marine unit (A64). In mid-2018, Norwegian Kongsberg was disclosed as the buyer (A65) with strong national interest to remain as a maritime frontrunner, and the acquisition was completed in spring 2019 (A66). We define this event as the end of phase 3, although other companies, including Kongsberg, nevertheless continue the development work, and individuals from RRM have since launched new start-ups in the field.

4.2. *Aligning resource configurations, value propositions, and institutional arrangements for autonomous shipping*

This section accommodates the chronological case narrative and its key events depicted in the previous section into the analytical dimensions of *resource configurations*, *value propositions*, and *institutional arrangements*. Table 1 features nine aligned change processes as composites of the elements and events that were portrayed in the case narrative. These change processes pave the way for autonomous shipping. For example, it was found that alignment of resource configurations manifests as aligned multi-level changes of “from machinery to IT”, “from hardware to software” and “towards intelligent use of data”. The following sections discuss the case regarding the analytical dimensions (see Appendix 6 for nuanced details).

4.2.1. *Aligning resource configurations*

Leveraging digital technologies to society’s best advantage means that there is a growing need for professional skills in e.g. information security, user experience, and service design, i.e. skills requiring more *intelligent use of data*. To educate the next generation of knowledge professionals, Finland added coding into its national basic education program in 2016 (A69). In higher education, the University of Turku was authorized in 2019 to establish a new Faculty of Technology (A70) to answer to a growing need for mechanical and digital technology professionals in industry. Besides human skills, autonomous solutions also require investments in public digital infrastructure. Here again, Finland has outlined a Digital Infrastructure Strategy 2025 (A71) to promote the implementation of 5G communications networks and support the related optical fiber construction.

These societal-level changes in resource configurations are likely to serve the future needs of the maritime sector, where we found workforce skillsets changing *from hardware to software*. The introduction of remote and autonomous solutions means that the new generation of seafarers need more software-related skills (A72). The same applies to the supplier side of the shipping industry. The industry’s competencies are changing as current suppliers change their resource bases directly (see discussion below), but established firms are also entering the marine industry from other industries through partnerships or joint research projects, e.g. Ericsson brought its communications technology competencies to the OneSea ecosystem (A36 & A73), and IT startups are entering the notoriously conservative industry, e.g. Flexport and Awake.ai.

On the actor level, delivering the changing customer value proposition required changes in RRM’s resources and competencies, which had traditionally been built on machinery-related engineering. This needed to be complemented with software development and marine operations skills. Consequently, the company established a Fleet Management Center in Norway, and set up a Ship Intelligence unit in Turku, Finland, which was later expanded into an R&D Center for Autonomous Ships (A74). This move was in sync with the education policy changes in the Turku region, which were advocated by the management of RRM. Furthermore, the demise of Nokia in Finland (see e.g. Lamberg, Lubinaitė, Ojala, & Tikkanen, 2019) meant that RRM was able to scout mobile communications technology professionals, and it supported the setting up of a start-up led by four ex-Nokians specializing in sensor technologies. Master mariners were also hired to work at the R&D Center to ensure remote control and autonomous solution development based on user experience. Lastly, during our period of observation, RRM formed partnerships with companies representing vessel ownership (Svitzer and FinnFerries), and various areas of innovation needed for remote control and autonomous shipping to realize, including Intel (A75), ESA (A49), AXA (A76), and Google (A48).

Table 1
Summary of aligned multi-level changes advancing autonomous shipping.

Levels of service ecosystem/ Alignment elements	*Resource configurations*	*Value propositions*	*Institutional arrangements*
Society	Towards intelligent use of data	Towards a more intelligent knowledge society	Towards smart robotics and automation
Stakeholder system	From hardware to software	From shipping efficiency to smart logistics	From silence to sharing
Actors	From machinery to IT	From granular functions to integrated processes	From product orientation to service orientation

4.2.2. *Aligning value propositions*

Digitalization penetrates all areas of society, where the inclusion of autonomous solutions suggests that societal issues (e.g. healthcare provision, organizing transportation, public administration decision-making) can be solved with higher quality and cost efficiency. The focus is shifting away from merely producing, distributing, and processing large volumes of data towards its analysis and integration into services that best support different areas of human life (cf. A68). Digital technologies such as IoT, AI and robotics aim to perform routinized and computational tasks better than humans, thus leaving us with tasks requiring humane traits such as empathy and creativity. In other words, our findings indicate that the increase of autonomous solutions in society is changing its value proposition *towards a more intelligent knowledge society*.

We also found the changing societal value proposition to mirror the shifting value proposition of the marine industry, where discussion about automation began with a focus on autonomous ships, and what opportunities they offered to improve shipping efficiency. An example of this was the establishment of the MUNIN (A1) and AAWA (A19) research projects. Gradually however, discussion on the stakeholder system level evolved to consider shipping as part of the larger transportation system, and towards intelligent logistics made possible by autonomous solutions spanning industry borders. In other words, the value proposition of the industry evolved *from shipping efficiency to intelligent logistics*, or from vessel efficiency to seamless port-to-port and even door-to-door integration. This could be seen to manifest e.g. in the establishment of the Finnish Design for Value (D4V) project focused on autonomous logistics chains. Besides marine industry, it included firms from e.g. telecommunications and manufacturing industries.

During our period of observation, RRM was a central actor in driving the autonomous shipping vision forward in the marine industry and spearheaded the AAWA and D4V projects. Thus, it was able to influence the changing stakeholder system value proposition to support its own customer value proposition, which changed *from granular functions to integrated processes*. This meant change from mere asset value derived from individual vessel equipment or systems (e.g. powerful engine or propulsion) to business value derived from integrated data-driven solutions that optimize vessel and fleet performance. Through such ship intelligence solutions, the customer could expect enhanced profitability, safety, control, reliability, predictability, and lowered emissions (A67). This moved RRM from an equipment supplier to a solution supplier, thus tapping into a larger “share of customer wallet”.

4.2.3. *Aligning institutional arrangements*

In 2016, the Finnish Government outlined a resolution to increase the development, use, and commercialization of *smart robotics and* *automation* in Finnish society (A68). This has translated into 1) publicly funding the emergence of ecosystems and networks developing robotics and automation solutions (e.g. the AAWA and D4V projects and OneSea ecosystem, all led by RRM), 2) developing regulation to support systems development (e.g. allowing autonomous solutions to be tested in allocated Finnish waters (A37, as a result of RRM's lobbying)), and 3) supporting new education programs (see above). Besides regulatory support, societal acceptance for autonomous solutions has also been actively driven by e.g. the University of Helsinki and Reaktor Oy together offering a free, open online course "Elements of AI" (A77), with the aim of "*helping people to be empowered, not threatened, by artificial intelligence*".

Necessitating vast cooperation, the deployment of smart robotics and automation in the marine industry appeared to shift the industry's ways of working *from silence to sharing.* In 2014 when the AAWA project composition was being negotiated, two large engine manufacturers could not "fit" into the same research project. Today however, they and others are part of the OneSea ecosystem (A36). Similarly, seafarers' unions' reaction to autonomous shipping was first feared, but as seafarers were included in the testing of sensor fusion on a ferry in Finland, those fears faded and turned into mutual knowledge sharing (meeting notes with startup technology supplier CEO, 2017). Furthermore, with more actors around the world joining the automation bandwagon, in 2017 the IMO included the issue onto its regulatory development agenda (A63), thus providing institutional support for the deployment of autonomous solutions in shipping.

Developing autonomous solutions and the related cooperative mindset supported RRM's business shifting increasingly *from a product orientation to a service orientation*. In line with the changing customer value proposition and resource base, RRM's business model changed to include more service offerings instead of mainly relying on equipment manufacturing. This was manifested in the provision of solutions such as predictive equipment maintenance based on data management, and intelligent awareness data fusion system assisting human navigators (A67). Such service orientation was not new to the RR group, where a "power by the hour" business model had been used in its aviation business for years (see Smith, 2013; Wilkinson, Dainty, & Neely, 2009), which supported the efforts of the Ship Intelligent unit's innovators to introduce service business models to RR's marine business. Nevertheless, rolling out the new service offerings was hindered by e.g. a sales force of engineers used to selling equipment only (meeting notes with R&D manager 1, 2017).

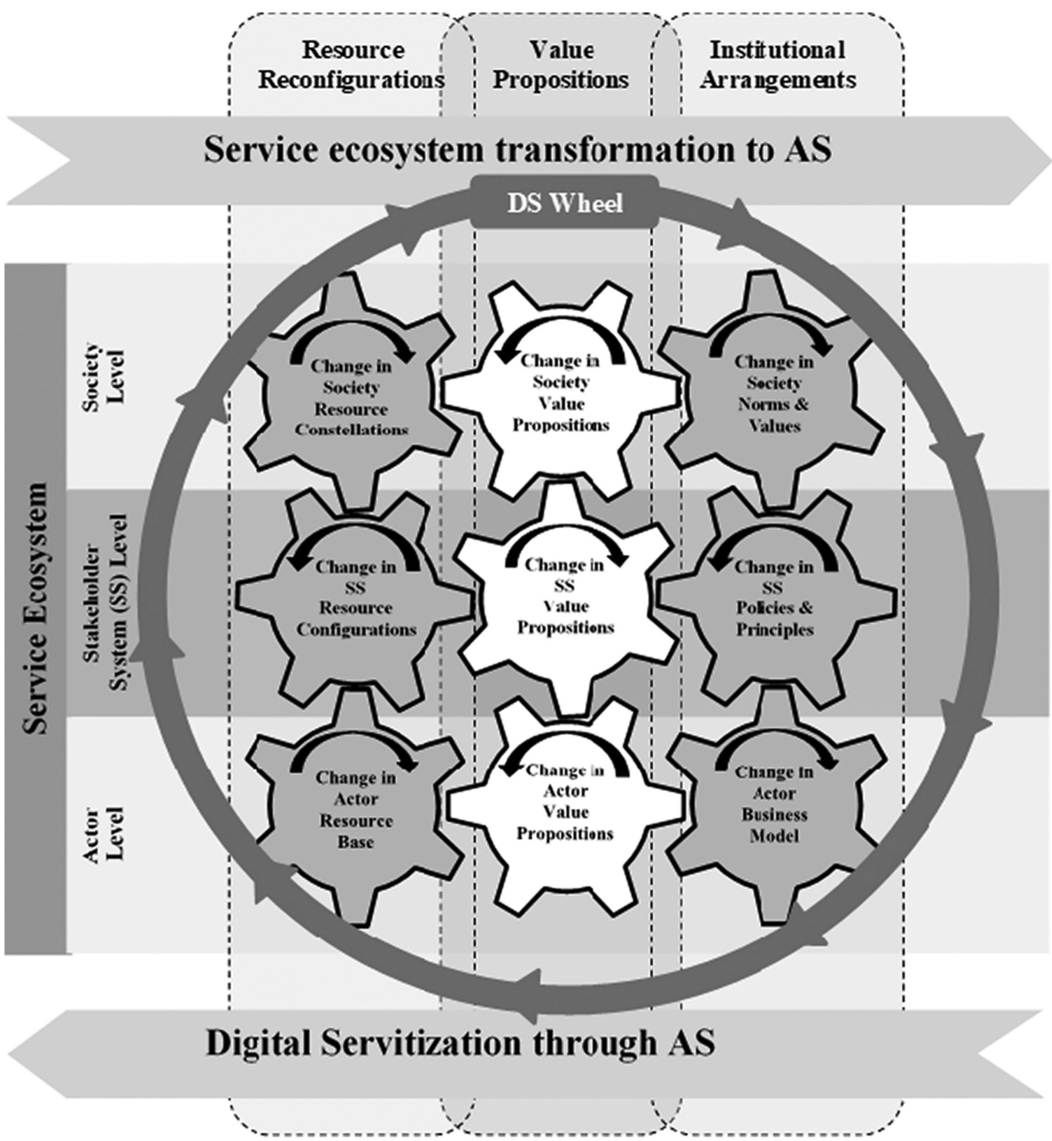

Fig. 3. Empirically enriched framework of DS through autonomous solutions.

5. Discussion

5.1. DS process in the context of service ecosystem transformation

Our findings suggest that DS through autonomous solutions necessitates the co-evolution of actor, stakeholder system, and society levels of a service ecosystem, thus advocating the need for a systems perspective to DS management. Fig. 3 features a DS Wheel as a circle that connects an actor driven DS process and a collective service ecosystem transformation process with nine service ecosystem elements (depicted as gears) (the form of the figure is inspired by Makkonen, Saarikorpi & Rajala, 2019). The spinning of the DS Wheel visualizes the outcome of consistent DS management by the focal actor. Fig. 3 illustrates the challenge of alignment horizontally within the levels and across them on the vertical pillars of resource configurations, value propositions and institutional arrangements. Depicting the service ecosystem elements in the form of gears communicates their interconnections: i) syncronized spinning of the gears (see black arrows in gears) reinforces the spin of the DS Wheel and feed the DS process and service ecosystem transformation to proceed, ii) any of the gears may resist the spinning of the DS Wheel and thus hinder the progress of the DS process and service ecosystem transformation. Respectively, the focal DS company aims at i) facilitating the creation of necessary resource configurations, value propositions and institutional arrangements on each level, and ii) achieving consistencies between these elements both within and across the levels, to support DS process and service ecosystem transformation to autonomous solutions.

The actor level in the framework refers to the focal servitizing actor and other relevant actors that connect to the focal DS process. The changes on the actor level cover actors whose mutual resource integration patterns form the stakeholder system. The stakeholder system may contest the society-level dominant resource constellations, value propositions and norms and rules, i.e. form bottom-up dynamics within the service ecosystem. Similarly, top-down dynamics may manifest in a change on society-level norms and rules that open up opportunities and motivate the individual actors and a stakeholder system to develop new resource constellations and value propositions to realize the society-level opportunity.

Altogether, these considerations lead us to formulate Propositions 1–6 (see Table 2) which aim at communicating the overall picture of the dynamics between a focal DS process through autonomous solutions and related service ecosystem transformation. The next sections exemplify DS management in the context of service ecosystem transformation to autonomous solutions on all the levels, as presented in Fig. 3.

5.2. Managing a DS process in the context of service ecosystem transformation

5.2.1. Engaging actors for systemic change

Extant research on DS has largely focused on focal company transformation (e.g. Bustinza et al., 2018; Vendrell-Herrero et al., 2017) through its attempts to develop novel resources and business models (Coreynen et al., 2017). Furthermore, research has identified DS ramifications for customer companies (Kamalaldin et al., 2020; Kohtamäki et al., 2019; Tronvoll et al., 2020), and needs for developing customer collaboration (Sjödin et al., 2020) and DS implementation capabilities (Raddats et al., 2019)). Thus, previous DS research is largely actor-centric, yet autonomous solutions require various actors to drive the systemic change of service ecosystem transformation, as called for by e.g. Appio et al. (2021). This implies that the focal emerging autonomous solution is not fully covered nor controlled by the DS actor but links with other emerging digital solutions, elements and actors in the service ecosystem that are necessary complements to form a viable systemic entity (see Nambisan et al., 2017). This suggests seeing a DS actor as a *driver* that aims at proceeding the DS process and leverage it for service ecosystem transformation. This study shows how RRM was a driver-actor in pushing the global maritime ecosystem towards autonomous solutions. In other words, RRM realized that to enable its DS process, the service ecosystem transformation needed to be facilitated, as the DS process and the service ecosystem transformation became largely inseparable entities in RRM's actions.

Furthermore, the study shows how RRM engaged businesses, research institutions, governmental agencies, and universities to join the process in a *complementor* role. We define complementors as actors who facilitate the focal company in its DS process. In addition to

Table 2
Propositions for fostering autonomous solutions development

Level	Proposition
Inter-level Propositions	**P1:** DS through autonomous solutions requires aligned resource configurations across each level of a service ecosystem. **P2:** DS through autonomous solutions requires articulation of attractive aligned value propositions across each level of a service ecosystem. **P3:** DS through autonomous solutions requires aligned institutional arrangements across each level of a service ecosystem. **P4:** DS through autonomous solutions requires aligned value propositions, resource configurations and institutional arrangements within each level of a service ecosystem. **P5:** DS and service ecosystem transformation reinforce each other via service ecosystem elements. **P6:** The elements of value propositions, resource configurations, and institutional arrangements within each level of a service ecosystem may comprise enablers and disablers for DS through autonomous solutions.
Actor-level Propositions	**P7:** The DS company needs to build an extensive outward view of the short and long-term needs and motives of the driver and complementor actors to facilitate their engagement. **P8:** The DS company needs to build an inward view regarding its resource base and business model, and understand how to reconfigure them to realize the value propositions. **P9:** DS through autonomous solutions may better fit with the prevailing business model of some actors and require more extensive modifications and business model renewal for others.
Stakeholder System-level Propositions	**P10:** The composition of the stakeholder system may alter as the service ecosystem transformation progresses from early development of technology to the eventual institutionalization of autonomous solutions in a service ecosystem. **P11:** The stakeholder system value proposition may alter as the service ecosystem transformation progresses from early development of technology to the eventual institutionalization of autonomous solutions in a service ecosystem. **P12:** Stakeholder system value proposition may engage actors from a variety of industries to join the development efforts **P13:** Stakeholder system policies and principles are key to support the formation of a culture of sharing instead of secrecy between the actors in a stakeholder system for autonomous solutions.
Society-level Propositions	**P14:** Actors may facilitate service ecosystem transformation to autonomous solutions by aligning the stakeholder system value proposition with the societal value proposition **P15:** Actors may facilitate service ecosystem transformation to autonomous solutions by including elements of the societal value proposition into stakeholder system policies and principles **P16:** The more visible and explicit the actions and outcomes of the stakeholder system are, the more they contest the prevailing societal values and norms, and provide opportunities for aligning actions. **P17:** The collaboration and competition between stakeholder systems facilitate service ecosystem transformation to autonomous solutions.

accommodating complementors to the focal RRM-driven DS process, RRM inspired and facilitated complementors in developing their own ideas and initiatives regarding the launch of their own DS processes and thus become drivers. The rationale for RRM was to gain critical mass and momentum by leveraging the DS processes to facilitate service ecosystem transformation.

In terms of managing the DS process through autonomous solutions, it is essential to identify and activate complementors and drivers to engage in the focal DS process and launch the parallel ones. This requires crafting different types of value propositions recognizing versatile actors' perspectives regarding the service ecosystem transformation. The extensive outward view of the focal DS company requires visioning capabilities to sketch a feasible roadmap of technology development, and determine what the potential use cases for autonomous solutions are. Moreover, it needs to find ways to (re)organize its resource base and business model to support short and long-term value propositions for customers, drivers and complementors. Different phases in the service ecosystem transformation to autonomous solutions require different types of resources. This increases the difficulty for the focal DS company to set attractive value propositions, as the complementors may be motivated by the ultimate goal of the transition to a particular autonomous solution (e.g. autonomous shipping), or by minor goals to pursue opportunities for networking and technology development. These considerations are formulated into propositions P7-P9 in (Table 2).

5.2.2. Balancing between the individual and collective: Maneuvering the autonomous solutions stakeholder system

Previous research has focused on creating interfaces between network members for aligning their activities to develop systemic offerings (see Kamalaldin et al., 2020; Vendrell-Herrero et al., 2017). This study shows that for the focal DS actor, managing the stakeholder system refers to i) steering how actors align resources into resource configurations, and ii) influencing the policies and principles that facilitate resource integration in the stakeholder system. Here, the value propositions on both actor and stakeholder system levels are key devices.

Stakeholder system in the focal case refers to the composition of drivers and complementors that link to the DS processes driving the transformation to autonomous shipping. The stakeholder system value proposition motivated these actors to engage in the development. The stakeholder system value proposition is partly a vision created by driver (s) but at the same time emerges as a result of actors engaging in mutual resource integration. RRM for instance aimed at creating general awareness and visualizing the value proposition of the upcoming autonomous shipping market and its benefits and requirements for the key actors. The stakeholder system value proposition of "Redefining shipping" was an umbrella that linked together and aimed at reinforcing the various subprojects on technology, market and social dimensions of autonomous shipping development. Crafting, visualizing and communicating strong reciprocal value propositions for all the key actors facilitated the actors to realize the need for joint action to gain momentum towards autonomous shipping.

The stakeholder system evolves as the transition to autonomous solutions may remove the need for certain actors, or introduce a need for new ones. For instance, the transition to autonomous shipping introduces a need for a remote control centre operator. It is up to the driver actors in the stakeholder system to envision the future composition of actors in the service ecosystem based on the resources needed to realize the value proposition, and engage in resource integration accordingly. The evolvement of the stakeholder system reflects upon the needs to revise policies and principles that provide support and guidance for how the actors are assumed to collaborate and integrate resources. While it is likely that both competitive and cooperative relationships exist between the actors in a stakeholder system, the complexity of autonomous solutions necessitates a culture of sharing between the actors. This posits balancing between collaboration and competition (see Kamalaldin et al., 2020; Paschou et al., 2020; Vendrell-Herrero et al., 2017) as a central feature of stakeholder system policies and principles. These considerations led us to formulate propositions P10-P13 in Table 2.

5.2.3. Navigating the society-level tail- and headwinds

Systems-level studies on DS processes are growing in number (Parida et al., 2019; Paschou et al., 2020), and according to our findings, the systemic nature of autonomous solutions steers the focus towards society-level change, as for instance Appio et al. (2021) have acknowledged. The transformation towards autonomous solutions links directly with its effect on increasing the welfare of society sustainably. In terms of autonomous shipping, its potential effects on improved maritime safety, working conditions, and lower environmental burden are elements of both stakeholder system and societal value propositions. A strong societal value proposition in turn facilitates change in the norms and values that eventually define the political, legal and social acceptability of autonomous solutions in general.

DS management on the society level refers largely to sensing the directions of societal development regarding value propositions and evaluating the related resource configurations and institutional arrangements, i.e. norms and values. The society level indicates the upcoming opportunities that guide the actors and the stakeholder system top-down in responding to these opportunities. Simultaneously, the actor and stakeholder system-level DS processes create active bottom-up pressure that contest the dominant societal order and reveal the needs and opportunities for change. The focal DS actor may demonstrate and explicate the societal opportunities and turn them into value propositions regarding each actor and the stakeholder system. In the focal case, RRM aimed at high public visibility and awareness for its vision of autonomous shipping to stimulate the society level and related actors, such as the IMO and national regulators to get approval to test the technologies in different countries. Society-level institutional arrangements in terms of legislation promoted uncertainty, shifting the focus towards a slow, long-term change process instead of a short-term orientation. The need for legislative change and definition of unmanned functions and related liabilities in the global maritime sector disabled fast development. However, showcases of technology were used to illuminate the stakeholder system capabilities to drive change in the society-level resource configurations to backbone autonomous solutions and demonstrate the related opportunities for improving societal functions, i.e. offer novel value propositions. Engaging actors whose actions focus on the society level, e.g. modifying the legal-political framework and societal acceptance, may facilitate the alignment of the societal value proposition and the stakeholder system value proposition. In addition, the more visible and concrete outputs the stakeholder system achieves in terms of proof-of-concepts and demonstrations, the more explicit their (mis)fits with society-level values and norms become.

Rapid changes in the IMO agenda were interpreted as promising signs and facilitated industrial convergence by providing concrete opportunities in, for example, developing technologies and joint processes for autonomous solutions at the crossroads of various autonomous solutions-related stakeholder systems. A parallel stakeholder system for the studied global maritime stakeholder system was the autonomous driving stakeholder system and DS processes of different car manufacturers. Different stakeholder systems synergize together in developing concrete solutions that take the service ecosystem transformation further, thus shaping DS opportunities of the focal servitizing company in any specific area of application. These considerations are formulated into propositions P14-P17 in Table 2.

6. Conclusions

6.1. Theoretical contributions

The study offers two interrelated contributions. First, the study provides an analysis of a nascent area of autonomous solutions in DS research (see Parida et al., 2019). Currently, autonomous solutions represent the most complex and interlinked end of digital technologies that widely connect the focal servitization company to its business and societal contexts (Iansiti & Lakhani, 2014; Porter & Heppelmann, 2015, 2017; Saidani et al., 2020). Such interconnecting nature of autonomous solutions proposes to extend analysis from a focal company-focal technology –setup, thus supporting the emerging research on DS that has taken steps towards systemic approaches (Kohtamäki et al., 2019; Polova & Thomas, 2020; Sklyar et al., 2019). More broadly, our study parallels the emerging body of literature on Industry 4.0 (see Frank et al., 2019; Meindl et al., 2021) which incorporates multiple levels of analysis in exploring the relationship between digital transformation, servitization, product-service systems, and digitalization in industry. Specifically, our study operates at the intersection of the Industry 4.0 dimensions of Smart Products and Services and Smart Supply Chains (see Meindl et al., 2021).

Secondly, the study contributes by building towards a contextual account of DS. The literature review by Paschou et al. (2020) calls for research to explicate the systemic and holistic nature of DS, with previous research largely neglecting the broader role of ecosystems and society in enabling completely new forms of business. This study sheds light on the interplay between a focal company's DS actions and the contextual dynamics with its focus on linking DS to service ecosystem transformation. The study puts forward an empirically enriched framework and extensive set of propositions, thus providing a roadmap to articulate the different levels and units of analysis for designing specific research setups that concretize and further develop our understanding of the multilayered nature of autonomous solutions.

6.2. Managerial implications

For DS managers, the provided framework provides a holistic platform that can be used for gaining and unifying information from various sources. Managers may define the key society-level forces that drive or hinder the development in a given area of application, and therefore understand the opportunities and threats associated with a DS strategy. This calls for the utilization of different tools such as scenario work when visioning the potential of the autonomous solutions business. Similarly, managers can systematically identify parallel stakeholder systems, and whether the focal company should join some existing stakeholder system or start to create and drive a new one: who are the drivers and complementors, and what are their resources and motivations that drive their engagement in the DS process and service ecosystem transformation.

The framework provides an opportunity to sketch a trajectory of the service ecosystem transformation and analyze the focal firm's potential role in it. Such analysis should focus on the implications and needed modifications to the company business model and resource base: what kind of opportunities the transformation offers in terms of collaboration and competition, and what are the respective strategic decisions to make regarding changes to the company resource base and business model. Particularly, managers should build a resource roadmap, i.e. what resources the company needs to build, acquire, and integrate to thrive in the era of autonomous solutions. More widely, the framework can be used on a stakeholder system level to build a shared mental model and language of the transformation dynamics. This would enable the actors to build and agree upon stakeholder system rules, principles and actor roles.

6.3. Limitations

The limitations of the study stem from the chosen context and methodological choice. This study sheds light on how a focal company initiates towards commercial autonomous shipping. Such a case features an extreme in its extensiveness of autonomous solutions, tapping maritime industry as a system connected to global systems of transportation, logistics, and technology development, and embedded into supranational macro-environmental dynamics. Not all autonomous solutions comprise such complex and interlinked entities (cf. Thomson et al., 2021) with thick institutional arrangements throughout all the levels. For example, autonomous solutions are already in place in more restricted scopes of application such as heavy machinery in factories, or household products. Thus, the focal study emphasizes autonomous solutions that have tremendous capacity to alter various industries and service ecosystems.

As a single case study, it aims at theoretical generalizations (Eisenhardt, 2021). The main target of the findings is thus to build theoretical perspective and conceptualization, not to pose assertions regarding causal construct relations. Thus, generalization of the results to other contexts of service transitions to autonomous solutions must be made with care. Similar development in other sectors may differ from the autonomous shipping context, as the magnitude of external forces may vary in terms of the role of politics, technological development, and legislation. However, the developed framework and propositions may provide structure for subsequent quantitative studies to attain more widely generalizable results. Future studies would also benefit from the use of different units of analysis. For instance, analyzing autonomous solutions through relationship-level lenses for implementing them in key supplier/buyer relationships and networks as collective action could provide deeper understanding of the phenomenon and facilitate research design to state stricter assertion on construct causalities.

Acknowledgment

The authors wish to thank Business Finland, the Finnish Funding Agency for Technology and Innovation, for funding this research (grant numbers 5078/31/2014 and 7673/31/2016).

Appendix 1. Summary of data sources

Purpose	
Primary data sources	16 semi-structured interviews of 29 informants inside and outside the consortia (all but 2 recorded and transcribed, notes taken, length varied between 40 and 110 min) 9 structured marine stakeholder interviews, outside the consortia 6 firm-specific workshops for consortia members with 6–9 participants in each workshop (researcher-facilitated future autonomous shipping vision and related business networks illustration exercise) Observations and field notes from 37 meetings and internal project seminars Field observations from 14 industry seminars and trade fairs
Areas of expertise of tech suppliers' informants	Remote control center, communications, operation optimisation, remote controlled systems, situational awareness systems, general firm R&D.
Areas of expertise of stakeholder informants	Ship ownership, ship management, autonomous driving
Secondary data sources	Over 300 secondary data sources include news and blogs, company publications, presentation materials, webinars and videos, industry reports and white papers, and magazine issues.
Broad topics of secondary data	Autonomous shipping, autonomous supply chains, autonomous driving, autonomous aviation, digitalization, big data, IoT, AI, and robotics.

Appendix 2. Interview guide

Introductory questions

- Please describe your background and role in the organization?
- How is digitalisation influencing the marine industry?
- Have you made any preparations for autonomous shipping becoming a reality? Why/why not? What kind of actions you have taken?
- What costs, benefits, opportunities and threats do you see for autonomous shipping becoming a reality in general?

Opportunities, challenges and effects on business posed by autonomous shipping

- In what ways could autonomous shipping be beneficial / destructive to your business?
  o What challenges does autonomous shipping pose for your company?
  o What new business opportunities could autonomous shipping create for your company?
- Describe your skills and competencies that could be utilized in autonomous shipping?
- What new competencies/structures/processes would autonomous shipping require from your company?
- What kinds of effects would autonomous shipping have on your stakeholder relationships?
- Who benefits/looses the most in the transition to autonomous shipping, why?
- What kinds of new cooperative networks would autonomous shipping create for your company?
- How would autonomous shipping fit with your current business model?
- How would autonomous shipping fit with the business models of the current actors in the maritime sector?

Technological readiness (per technology area)

- Which technology areas are necessary to realize autonomous shipping?
- Which technologies need further development for autonomous shipping?
- What new skills and competencies do these technologies require from the people operating them?
- How will the current actors fit with technological requirements regarding autonomous shipping?
- What new capabilities are needed and who will be the actors to best demonstrate them within the current maritime sector? What are the key related sectors and type of potential actors?

Implementation network and the operational/institutional environment

- How can development in autonomous shipping move from developing individual technologies to integrating them systemically? What are the factors that hinder/facilitate this in the current operational/institutional environment?
- Who should be the integrator and what type of other roles are to emerge/be needed? What are the factors that influence the role taking/acting?
- If new actors are needed, what type and what are the potential sectors to converge with the maritime sector in autonomous shipping?
- What kinds of changes would autonomous shipping cause in the relationships between the actors in the maritime industry? Possible conflicts? New type of relationship needed?
- What kinds of political / economic / legal / cultural factors are involved in the introduction of autonomous shipping and it becoming more common?
- What are the key drivers/inhibitors in the global/regional macro-environment for autonomous shipping?
- Who are the key actors in the global macro-environment to influence the autonomous shipping development?
- How does the marine industry generally react to technological innovations in shipbuilding?

Appendix 3. Coding structure

Analytical concepts		First-order categories	Second-order integrative themes	Empirically enriched framework
Resource configurations	Society	- Digital technologies requiring new types of professional skills in society - Educating the next generation of knowledge professionals - Investments in public digital infrastructure	Towards intelligent use of data	An empirically enriched framework and a set of propositions for aligning Resource configurations, Value propositions and Institutional arrangements within and between the levels of Actor, Stakeholder system, and Society
	Stakeholder system	- Seafarers needing software-related skills - Equipment suppliers needing software-related knowledge - ICT firms entering the marine industry	From hardware to software	
	Actor	- Establishing units specializing in data-led business - Hiring ICT and user experience experts - Forming R&D partnerships for autonomous solutions	From machinery to IT	
Value propositions	Society	- Autonomous solutions developed to solve various societal issues - Focusing on data analysis and integration	Towards a more intelligent knowledge society	

(continued on next page)

(*continued*)

Analytical concepts		First-order categories	Second-order integrative themes	Empirically enriched framework
	Stakeholder system	- Optimizing the potential of digital technologies and humane traits in society - Autonomous solutions for vessel efficiency - Autonomous solutions for door-to-door integration - R&D projects spanning industry borders	From shipping efficiency to smart logistics	
	Actor	- Offering equipment for vessel efficiency - Offering integrated data-driven solutions for fleet optimization - Changing role from equipment supplier to solution supplier	From granular functions to integrated processes	
	Society	- Public funding supporting robotics & automation R&D projects - Regulatory support for the deployment of autonomous solutions in society Societal acceptance for autonomous solutions	Towards smart robotics and automation	
Institutional arrangements	Stakeholder system	- Formation of research consortia for autonomous solutions in shipping - Equipment suppliers working with seafarers for user experience optimization - International regulatory development and support	From silence to sharing	
	Actor	- Developing service business models in commercial marine business - Learning from other business areas already deploying service business models - Educating equipment sales personnel to sell service offerings	From product orientation to service orientation	

Appendix 4. Trustworthiness of the study

Criterion	Addressed method
Pre-understanding	Pre-understanding of autonomous solutions was gained by familiarizing ourselves with the phenomenon (media presentations, Internet searches, collection of secondary data) concerning different industries (maritime, aviation, automotive)
Credibility (Internal validity)	Four years of continuous interaction with case firm's representatives for member checks 6 firm-specific full day workshops with 6–9 industry representatives in each Extensive secondary data collected Different researchers conducted research interviews Feedback from industry representatives from presentations held at public industry seminars and project seminars Interim project reports provided to the case company and other member companies of the two research consortia
Transferability (External validity)	16 interviews representing different organizational functions, and 6 different nationalities were interviewed during the research process Use of purposeful sampling method Thick description of the case narrative Data set covers different transportation industries in different national contexts
Dependability (reliability)	In workshops, participants commented on their experiences as firm's representatives from different functions and different levels of seniority Nvivo 12 program was used to analyze the data Use of data triangulation technique for verification Memos collected from the workshops Secondary data were open for everyone
Confirmability (Objectivity)	Case firm's representatives gave feedback of the preliminary results Researchers wrote a whitepaper with the case firm's representatives and a booklet regarding the phenomenon to the university's publication series Researchers presented preliminary results of the study in research conferences and internal industry-academia project seminars

Appendix 5. List of public secondary sources

A1. MUNIN – Maritime Unmanned Navigation through Intelligence in Networks. http://www.unmanned-ship.org/munin/
A2. Rosendahl, J. (2011). Wartsila to buy Hamworthy for £383 million. https://uk.reuters.com/article/uk-hamworthy-wartsila/wartsila-to-buy-hamworthy-for-383-million-idUKTRE7AL0R520111122
A3. Eskola, J. (2014). Wärtsilä to acquire L-3 marine systems international. Press conference 16.12.2014. https://cdn.wartsila.com/docs/default-source/investors/financial-materials/other-ir-presentations/acquisition-of-l-3-marine-systems-international-16-12-2014.pdf?sfvrsn=cfa2f645_8
A4. The Economic Times (2014). Rolls-Royce looked to buy out Finland's Wartsila. https://economictimes.indiatimes.com/news/international/business/rolls-royce-looked-to-buy-out-finlands-wartsila/articleshow/28600772.cms

(*continued on next page*)

(*continued*)

A5. Maritime Reporter TV. Digitization: The future is now. Greg Trauthwein interviews Esa Jokioinen. https://www.youtube.com/watch?v=igIzjyDgmls&

A6. Fimecc Publications Series No. 8. User Experience and Usability in Complex Systems – UXUS. Final Report. https://www.dimecc.com/wp-content/uploads/2019/06/FIMECC_FINAL_REPORT_8115_UXUS_Optimized.pdf

A7. Markoff, J. (2010). Google Cars Drive Themselves, in Traffic. https://www.nytimes.com/2010/10/10/science/10google.html

A8. BBC News (2013). Amazon testing drones for deliveries. https://www.bbc.com/news/technology-25180906

A9. Financial Times (2013) Rolls-Royce looks to plot a course to the future with drone ships. https://www.ft.com/content/b299c77c-6c00-11e3-85b1-00144feabdc0 (behind the paywall)

A10. Financial Times. No hands on deck: Dawn of the crewless ship. https://www.ft.com/content/e77b53e8-6c00-11e3-85b1-00144feabdc0 (behind the paywall)

A11. Daily Mail (2013). Dawn of the remote-controlled SHIP: Massive crewless vessels could soon set sail to save money and improve safety at sea. https://www.dailymail.co.uk/sciencetech/article-2529852/Dawn-remote-controlled-SHIP-Massive-crewless-vessels-soon-set-sail-save-money-improve-safety-sea.html

A12. Hegmann, G. (2013). Rolls-Royce glaubt fest an Drohnenschiffe. https://www.welt.de/wirtschaft/article123352845/Rolls-Royce-glaubt-fest-an-Drohnenschiffe.html

A13. Arnsdorf, I. (2014). Rolls-Royce Drone Ships Challenge $375 Billion Industry: Freight. https://www.bloomberg.com/news/articles/2014-02-25/rolls-royce-drone-ships-challenge-375-billion-industry-freight

A14. Manners, D. (2014). Unmanned, networked, intelligent ships navigate familiar water. https://www.electronicsweekly.com/blogs/viewpoints/unmanned-navigation-intelligence-networks-munin-2014-03/

A15. Laursen, W. (2014). Taking the safe path towards unmanned ships. https://www.motorship.com/news101/ships-equipment/taking-the-safe-path-towards-unmanned-ships

A16. Berrill, P. (2015). LR study lifts lid on ships and maritime technology of the future. https://www.tradewindsnews.com/weekly/lr-study-lifts-lid-on-ships-and-maritime-technology-of-the-future/1-1-367301 (behind paywall)

A17. Murray, K. (2016). Thought leadership and the demand for autonomous ships. https://www.tradewindsnews.com/weekly/thought-leadership-and-the-demand-for-autonomous-ships/1-1-383007 (behind paywall)

A18. Saarinen, M. (2015). Karmea eettinen pulma: Itseohjautuvat autot on pakko ohjelmoida tappamaan. https://www.iltalehti.fi/digi/a/2015102520555705 (Based on MIT Technology Review article)

A19. Haun, E. (2015). Rolls-Royce to Lead Autonomous Ship Research. https://www.marinelink.com/news/rollsroyce-autonomous394020

A20. Financial Times. Rolls-Royce to cut 400 jobs in marine division. https://www.ft.com/content/f789fa6e-6a91-11e5-aca9-d87542bf8673 (behind paywall)

A21. Blenkey, N. (2015). ABB unveils Integrated Operations Center. https://www.marinelog.com/news/abb-says-its-new-integrated-ops-center-will-bring-owners-big-savings/

A22. ABB press release (2015). ABB Steps Up Marine R&D with New Lab. https://new.abb.com/news/detail/51575/abb-steps-up-marine-rd-with-new-lab

A23. Wärtsilä press release (2016). Wärtsilä enhances its digital offering by acquiring Eniram. https://www.wartsila.com/media/news/30-06-2016-wartsila-enhances-its-digital-offering-by-acquiring-eniram

A24. BBC News (2015). Plymouth University's 'first' unmanned ship in Atlantic bid. https://www.bbc.com/news/uk-england-devon-33761960

A25. Kongsberg (2016). Automated Ships Ltd. and KONGSBERG to build first unmanned and fully autonomous ship for offshore operations. https://www.kongsberg.com/maritime/about-us/news-and-media/news-archive/2016/automated-ships-ltd-and-kongsberg-to-build-first-unmanned-and-fully-autonomous/

A26. Macdonnell Group (2016). https://www.youtube.com/watch?v=ALwx5VP8kWA&t=1s (not original)

A27. AAWA project (2016). Remote and autonomous ships: The next steps. https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf

A28. Safety4sea (2016). ABB: Five steps to autonomous operations. https://safety4sea.com/abb-five-steps-autonomous-operations/

A29. Wärtsilä press release (2016). Wärtsilä presents its 'visions of future shipping'. https://www.wartsila.com/media/news/06-09-2016-wartsila-presents-its-visions-of-future-shipping

A30. The Motorship (2016). Shipping and Finferries join autonomy project. https://www.motorship.com/news101/industry-news/esl-shipping-and-finferries-join-autonomy-project

A31. The Ministry of Transport and Communications of Finland press release (2015). Finland a good environment for experiments in automated transport. https://www.lvm.fi/en/-/finland-a-good-environment-for-experiments-in-automated-transport-796835

A32. Lighthouse (2016). Autonomous safety on vessels. https://www.lighthouse.nu/en/focus/lighthouse-reports/autonomous-safety-vessels

A33. Danish maritime authority (2016). The Danish Maritime Authority embarks on a future with unmanned ships. https://www.dma.dk/Presse/Nyheder/Sider/The-Danish-Maritime-Authority-embarks-on-a-future-with-unmanned-ships.aspx

A34. Autonomous ship symposium (2016). The path towards unmanned shipping. https://www.autonomousshipsymposium.com/en/

A35. Norway Exports (2016) Norwegian Forum for Autonomous Ships (NFAS) established. https://www.norwayexports.no/news/norwegian-forum-for-autonomous-ships-nfas-established/

A36. One Sea (2016). World's first system of autonomous ships kicks off at the Baltic Sea – DIMECC's innovation ecosystem brings forerunners and investments to Finland. https://www.oneseaecosystem.net/worlds-first-system-autonomous-ships-kicks-off-baltic-sea-dimeccs-innovation-ecosystem-brings-forerunners-investments-finland/

A37. One Sea (2016) DIMECC opens the first globally available autonomous maritime test area on the west coast of Finland – One Sea implementation moves forward. https://www.oneseaecosystem.net/dimecc-opens-first-globally-available-autonomous-maritime-test-area-west-coast-finland-one-sea-implementation-moves-forward/

A38. Schuler, M. (2016). Norway Designates First Drone Ship Testing Area. https://gcaptain.com/norway-designates-first-drone-ship-testing-area/

A39. Saito, M. (2016). Amazon expands logistics reach with move into ocean shipping. https://www.reuters.com/article/us-amazon-com-freight-idUSKCN0US2YW

A40. Constine, J. (2016). The unsexiest trillion-dollar startup. https://techcrunch.com/2016/06/07/flexport/?guccounter=1

A41. Start up Wharf. Maritime Startup Ecosystem Directory. https://www.startupwharf.com/startups/

(*continued on next page*)

(*continued*)

A42. IBM news release (2017). Maersk and IBM Unveil First Industry-Wide Cross-Border Supply Chain Solution on Blockchain. https://www-03.ibm.com/press/us/en/pressrelease/51712.wss
A43. Tradelens. Together, we can set trade free. https://www.tradelens.com/ecosystem
A44. EDI Weekly. Ghost ships: are we ready for autonomous super ships? BHP Billiton thinks we are, plans to utilize automated ships. https://www.ediweekly.com/ghost-ships-ready-autonomous-super-ships-bhp-billiton-thinks-plans-utilize-automated-ships/
A45. Rolls-Royce press release (2017). Rolls-Royce announces investment in Research & Development for Ship Intelligence. https://www.rolls-royce.com/media/press-releases/2017/08-03-2017-rr-announces-investment-in-research.aspx
A46. Peltoniemi, H. (2017). Satojen ihmisten vyöry Rolls-Roycen työpaikkojen esittelyyn Turussa. https://www.ts.fi/uutiset/paikalliset/3441054/Satojen+ihmisten+vyory+RollsRoycen+tyopaikkojen+esittelyyn+Turussa
A47. Rolls-Royce press release (2017). Rolls-Royce and MacGregor to explore implications of Autonomy for container ships. https://www.rolls-royce.com/media/press-releases/2017/27-03-2017-rr-and-macgregor-to-explore-implications.aspx
A48. Rolls-Royce press release (2017). Rolls-Royce joins forces with Google Cloud to help make autonomous ships a reality. https://www.rolls-royce.com/media/press-releases/2017/03-10-2017-rr-joins-forces-with-google-cloud-to-help-make-autonomous-ships-a-reality.aspx
A49. Rolls-Royce press release (2017). Rolls-Royce and the European Space Agency to collaborate on shipping's digital future. https://www.rolls-royce.com/media/press-releases/2017/30-11-2017-rr-and-the-european-space-agency-to-collaborate-on-shippings-digital-future.aspx
A50. Wärtsilä press release (2017). Wärtsilä strengthens its expertise in vessel positioning technology by acquiring Guidance Marine. https://www.wartsila.com/media/news/10-10-2017-wartsila-strengthens-its-expertise-in-vessel-positioning-technology-by-acquiring-guidance-marine
A51. Rolls-Royce press release (2016). Rolls-Royce to supply first automatic crossing system to Norwegian ferry company Fjord1. https://www.rolls-royce.com/media/press-releases/2016/18-10-2016-rr-to-supply-first-automatic-crossing-system-to-norwegian-ferry-company-fjord1.aspx
A52. Rolls-Royce press release (2017). Rolls-Royce and Stena Line to work together to develop intelligent awareness for ships. https://www.rolls-royce.com/media/press-releases/2017/20-03-2017-rr-and-stena-line-to-work-together.aspx
A53. Kongsberg (2017). YARA and KONGSBERG enter into partnership to build world's first autonomous and zero emissions ship. https://www.kongsberg.com/maritime/about-us/news-and-media/news-archive/2017/yara-and-kongsberg-enter-into-partnership-to-build-worlds-first-autonomous-and/
A54. Offshore Energy (2017). Japanese Consortium to Develop Autonomous Ocean Transport System. https://www.offshore-energy.biz/japanese-consortium-to-develop-autonomous-ocean-transport-system/
A55. Jiang, J. (2017). Unmanned Cargo Ship Development Alliance launched in Shanghai. https://splash247.com/unmanned-cargo-ship-development-alliance-launched-shanghai/
A56. Rolls-Royce press release (2017). Rolls-Royce demonstrates world's first remotely operated commercial vessel. https://www.rolls-royce.com/media/press-releases/2017/20-06-2017-rr-demonstrates-worlds-first-remotely-operated-commercial-vessel.aspx
A57. Wärtsilä press release (2017). Wärtsilä successfully tests remote control ship operating capability. https://www.wartsila.com/media/news/01-09-2017-wartsila-successfully-tests-remote-control-ship-operating-capability
A58. Wärtsilä press release (2018). Wärtsilä achieves notable advances in automated shipping with latest successful tests. https://www.wartsila.com/media/news/28-11-2018-wartsila-achieves-notable-advances-in-automated-shipping-with-latest-successful-tests-2332144
A59. Rolls-Royce press release (2018). Rolls-Royce and Finferries demonstrate world's first Fully Autonomous Ferry. https://www.rolls-royce.com/media/press-releases/2018/03-12-2018-rr-and-finferries-demonstrate-worlds-first-fully-autonomous-ferry.aspx
A60. ABB Group press release (2018). ABB enables groundbreaking trial of remotely operated passenger ferry. https://new.abb.com/news/detail/11632/abb-enables-groundbreaking-trial-of-remotely-operated-passenger-ferry
A61. Ship-Technology (2018). Rolls-Royce to provide autocrossing system for 13 Fjord1 ferries. https://www.ship-technology.com/news/rolls-royce-provide-autocrossing-system-13-fjord1-ferries/
A62. VPO Global (2018). Viking Line selects ABB marine automation system. https://vpoglobal.com/2018/11/15/viking-line-selects-abb-marine-automation-system/
A63. Safety4sea (2017). IMO puts autonomous ships on MSC 99 agenda. https://safety4sea.com/imo-puts-autonomous-ships-on-msc-99-agenda/
A64. Financial Times. Rolls-Royce considers sale of commercial marine unit. https://www.ft.com/content/1399b374-fb7d-11e7-9b32-d7d59aace167 (behind paywall)
A65. Jasper, C., Mulier, T. & Sleire, S. (2018). Rolls-Royce Offloads Ailing Marine Arm to Norway's Kongsberg. https://www.bloomberg.com/news/articles/2018-07-06/kongsberg-to-buy-marine-unit-from-rolls-royce-for-660-million (behind paywall)
A66. Kongsberg (2019). KONGSBERG completes Rolls-Royce Commercial Marine Acquisition. https://www.kongsberg.com/maritime/about-us/news-and-media/news-archive/2019/kongsberg-completes-rolls-royce-commercial-marine-acquisition/
A67. Rolls-Royce plc (2018) Redefining shipping. https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/RR-Ship-Intel-Broch-Oct2018.pdf
A68. Finland's Age of Artificial Intelligence - Turning Finland into a leading country in the application of artificial intelligence. Objective and recommendations for measures (2017) https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/160391/TEMrap_47_2017_verkkojulkaisu.pdf
A69. Codeschool (2019) Coding in Finnish curriculum. https://www.codeschool.fi/2019/04/finnish-curriculum/
A70. University of Turku press release (2019). University of Turku to Expand Master of Science Education to Mechanical Engineering and Material Technology – a Sustainable Solution for Expert Shortage. https://www.utu.fi/en/news/press-release/university-of-turku-to-expand-master-of-science-education-to-mechanical
A71. Ministry of Transport and Communications (2018). https://www.lvm.fi/-/digital-infrastructure-strategy-turning-finland-into-the-world-leader-in-communications-networks-985076
A72. Ift Global (2018) SkillSea - Future Skill and Competence Needs https://www.itfglobal.org/sites/default/files/node/resources/files/SkillSea%20project_Future%20Skills%20and%20competence%20needs_full%20report.pdf
A73. Ericsson plc (2018). Autonomous ships – Learning to sail in clouds https://www.ericsson.com/en/blog/2018/12/autonomous-ships–learning-to-sail-in-clouds

(*continued on next page*)

(*continued*)

A74. Rolls-Royce plc (2018). Rolls-Royce opens autonomous ship research and development centre in Finland https://www.rolls-royce.com/media/press-releases/2018/25-01-2018-rr-opens-autonomous-ship-research-and-development-centre-in-finland.aspx

A75. News Byte (2018). Intel Artificial Intelligence and Rolls-Royce Push Full Steam ahead on Autonomous Shipping https://newsroom.intel.com/news/intel-artificial-intelligence-rolls-royce-push-full-steam-autonomous-shipping/#gs.wl655o

A 76. Rolls-Royce plc (2018). Rolls-Royce and AXA to jointly develop risk management products for autonomous shipping https://www.rolls-royce.com/media/press-releases/2018/14-05-2018-rr-and-axa-to-jointly-develop-risk-management-products-for-autonomous-shipping.aspx

A77. Elements of AI. (2019). https://www.elementsofai.com/

A78. One Sea (2017). DIMECC leads digital disruption – New Systemic Renewal Program Design for Value Launched https://www.oneseaecosystem.net/dimecc-leads-digital-disruption-new-systemic-renewal-program-design-value-launched/

A79. University of Turku press release (2020). University's Eighth Faculty Strengthens Research and Education in Technology. https://www.utu.fi/en/news/news/universitys-eighth-faculty-strengthens-research-education-in-technology

A80. Ministry of Transport and Communications (2018). A Government resolution to promote the development of intelligent robotics and automation https://www.lvm.fi/en/-/a-government-resolution-to-promote-the-development-of-intelligent-robotics-and-automation

A81. Ministry of Transport and Communications (2018). Finland to take the lead in automation experiments in the maritime sector https://www.lvm.fi/en/-/finland-to-take-the-lead-in-automation-experiments-in-the-maritime-sector

Appendix 6. Examples of changes advancing autonomous shipping

Theme	Representative data
Towards intelligent use of data	"[Establishing the Faculty of Technology at the University of Turku] is a matter of sustainability and capacity across Finland. Due to the expansion of education engineering, we will have more expertise needed by the entire country, not to mention regional needs" (A79, Vice Rector of the University of Turku and the Director of the TechCampus Turku, University of Turku, 2020) "Our aim is to be the leading country in communications networks. The digital infrastructure must enable living, working and entrepreneurship across Finland. The needs of people, businesses and industry have been taken into consideration in the aims and measures of the strategy," says Minister of Transport and Communications Anne Berner. High-speed communications networks form the foundation of modern society and are a prerequisite for digitalisation. The strategy responds to global trends such as the growing role of artificial intelligence, data economy, automation, robotisation, internet of things and virtual reality in future applications and services. Also the development of autonomous transport on land, sea and air places high requirements for digital data and communications connections." (A71, Ministry of Transportation and Communications, 2018).
From hardware to software	"Many experienced captains have said that when you look at the junior captains, they completely trust the automation. They don't make decisions themselves, but they trust the automation to make the decisions. Old seadogs on the other hand do everything themselves and switch off all support systems. There are different schools of thought. But it's just natural evolution it's going towards." (R&D manager 4) "We need to change, culturally, the people onboard, the operators have to change from hammers and spanner type of activities on-board, to different, and more sophisticated, type of controls. […] It is evident that, in order to man a ship efficiently, we need a different breed of people. Unfortunately, current seafarers not all have the managerial approach that is required in this changing world. […] It is a challenge to have qualified people onboard, so you have to have more support from shore. You need to have people on shore that have a different background and a different type of managerial approach." (Ship management representative) "Finland's benefit is the telecomms skills, Nokia-driven, what we're good at. If you think about the mobile things they've done at Nokia previously, you get all sorts of services and usability things etc. I don't think we can suddenly invent a new nut that the whole world needs. But it must build from these skills somehow, when [Finnish maritime and ICT industries] are glued together" (R&D manager 1) We've started using a lot of ex-Nokia firms that you see around here too. In time, there are lots of them in Turku, Tampere, Helsinki, and everywhere, many of them Nokia spinoffs. Maybe all startups are starting to be Nokia spinoffs. But it's interesting how they bring a completely different approach to product development, how it's traditionally been done mechanically. (R&D manager 3) See also A2, A3, A20, A21, A23, A45, A46, A50, A65, and A66 for marine industry firms changing their resource bases; A36, A39, A48, and A49 for firms entering the marine industry from other industries; A4 and A40 for startups entering the marine industry; A34 and A35 for autonomous shipping forums.
From machinery to IT	"If you take Rolls-Royce or Wärtsilä or whatever marine industry firm, they're basically machine workshops. If you honestly go and take a look at what these types of firms really do, they're hitting sheets of steel together with a bloody big sledgehammer and make propellers and engines out of them. What we're going to need in the future is a completely different level of skills in terms of information communication technologies, cloud computing, automation, and robotics. Let's say in the next 5–10 years." (R&D manager 1) "I've recruited people from the seafarers side into our [autonomous technology development] team, and we've received an outrageous number of applications. Just recently I was looking for people for some automation side job, and there was a guy born in ́44 or something, just looking for new challenges." (R&D manager 5) "Rolls guys held a presentation at [Microsoft's (prev. Nokia] auditorium about their intelligent vessel and autonomous shipping vision, and that auditorium was packed, completely full, so it raised a lot of interest. They talked about wanting to do this but they cannot do it on their own and they needed a telecommunications technology expert to join in. Then we started to think about how to proceed, and we ended up thinking that the best thing would be a partner as its own firm who would execute the solution. […] They specifically wanted us to bring our perspective and skills etc., that we change the more traditional maritime business to this super modern mobile business, bring the best practices from there and learn from each other in the process." (Startup technology supplier CEO)
Towards a more intelligent knowledge society	"In another five years time, artificial intelligence will be an active part of every Finn's daily life. Finland will make use of artificial intelligence boldly in all areas of society –from health care to the manufacturing industry – ethically and openly. Finland will be a safe and democratic society that produces the world's best services in the age of artificial intelligence. Finland will be a good place for citizens to live and a rewarding place for companies to develop and grow. Artificial intelligence will reform work as well as create wellbeing through growth and productivity." (A68: Ministry of Economic Affairs and Employment, 2017, p. 14)
From shipping efficiency to smart logistics	See A9, A10, A11, A12, A13, A14, A15, A17, A19, A24, A25, A28, and A33 for articles covering autonomous ship development. "D4V enables the systematic change covering the whole supply chain. Although changes are ongoing in many fronts of the supply chain, the overall value network has not been disrupted yet. Without this kind of systematic approach the digital disruption of the overall value network would not be possible." (A78, SVP Technology & Innovation Management, Rolls-Royce Marine, DIMECC, 2017)

(*continued on next page*)

(*continued*)

Theme	Representative data
From granular functions to integrated processes	"We now have a business unit, Ship Intelligence, and in that we are focusing on developing three different types of offerings: first of all we are focusing on Health Management Solutions, so monitoring equipment onboard and providing remote assistance to the operators […] and dynamic maintenance planning etc. The second area is Optimization and Decision Support, which is today pretty much focused around energy consumption and that sort of things, but we are planning to extend that a little bit beyond, towards asset management and asset optimization type of services. So these are the two areas where we already have some offerings. The third area is more of a development pipeline at the moment towards the autonomous ship. That area is called the Autonomous and Remote Controlled Operations." (A5, Head of Blue Ocean Team, Rolls-Royce Marine in Maritime Reporter TV, 2016) See also A67, a sales brochure for Rolls-Royce Marine Ship Intelligence solutions (2018), for the end result of the autonomous and remote controlled operations development, which led to the provision of integrated ship intelligence solutions.
Towards smart robotics and automation	"In accordance with the resolution, Finland has to support the ecosystems and networks of automation and robotisation and promote the business opportunities through regulation, for example. Investments should also be made in increasing the expertise in robotics and automation, particularly in terms of information security, data protection, user-centred approach and service design. It is also important to increase the general acceptability of intelligent robotics and automation and to raise awareness of the phenomena related to them." (A80, Ministry of Transportation and Communications, 2016) "Finland has highlighted the opportunities of digitalisation in the International Maritime Organization, IMO. Both in the IMO and in developing the European Union maritime transport services, Finland is working for the efficient use of digitalisation and automation," (A81, Ministry of Transport and Communications, 2016) "We want to encourage as broad a group of people as possible to learn what AI is, what can (and can't) be done with AI, and how to start creating AI methods." (A77, Elements of AI)
From silence to sharing	"The situation was that when this was discussed [in 2014], this unmanned-project [AAWA], it was seen that it needed a strong leader. So the choice was whether Wärtsilä, Rolls Royce or ABB should take it. After one meeting, Wärtsilä and ABB informed that they won't take it. […] I thought it was funny how both of them just said 'no thanks, we won't take it'." (Ship design representative 1) " It's pretty rare that competing tech firms commit to the same industrial strategy, directly just like that. Now we have that support and we just have to see that when our competitors are there it's beneficial to us. We have many things in Finland to invest in, so it's not worth competing with each other in everything. […] This is different than doing everything in secret, trusting we do it best, and no one knows what's happening. This is a completely opposite approach, that we've been going into this publicity first." (R&D manager 2) "It's a strategic choice that we want to be a thought leader in this. That's why we talk about [autonomous and remote controlled ships]" (R&D manager 4) Conversation regarding two ship owners going public about their involvement in the AAWA research project: "I was really surprised that they went public with this" (Ship design representative 2) "It really surprised me too. I assumed that maybe the other one would stay completely quiet. But it was a positive surprise. Actually, it was interesting that they got away with it. It hasn't been used against them at all. So, so far none of the original fears have realized, as far as I know." (Ship design representative 1)
From product orientation to service orientation	"At the moment autonomy and other remote stuff doesn't really exist yet, but in other business areas equipment suppliers are selling these [maintenance and optimization] services as part of their service business, like Wärtsilä's Genius, each of us are doing the same thing. But these two service areas are such that they mainly support the suppliers' current product business. So most of it is monitoring their own equipment, optimizing their own equipment etc. so they're not very disruptive on their own. When we go to the remote and autonomy things, you can't just do your own thing anymore, because you're only providing a part of the solution to the customer." (R&D manager 2) "It's becoming more and more important, this ship intelligence service layer, on top of the other services. I strongly believe that in this whole industry, those who come out on top, are those who can glue that intelligence layer on there as well as possible. In Finland, we should have a pretty good base to build on, because we have other know-how than just thrusters in this country." (R&D manager 1) "[R&D manager 1] has had trouble educating sales personnel with an engineering background about how to start selling services as something other than just freebies on top of products" (Researcher's meeting notes, 2017)

References

Akaka, M. A., Vargo, S. L., & Lusch, R. F. (2013). The complexity of context: A service ecosystems approach for international marketing. *Journal of International Marketing, 21*(4), 1–20.

Akaka, M. A., Vargo, S. L., & Schau, H. J. (2015). The context of experience. *Journal of Service Management, 26*(2), 206–223.

Appio, F. P., Frattini, F., Petruzzelli, A. M., & Neirotti, P. (2021). Digital transformation and innovation management: A synthesis of existing research and an agenda for future studies. *Journal of Product Innovation Management, 38*(1), 4–20.

Beverland, M., & Lindgreen, A. (2010). What makes a good case study? A positivist review of qualitative case research published in Industrial Marketing Management, 1971–2006. *Industrial Marketing Management, 39*(1), 56–63.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Bustinza, O. F., Gomes, E., Vendrell-Herrero, F., & Tarba, S. Y. (2018). An organizational change framework for digital servitization: Evidence from the Veneto region. *Strategic Change, 27*(2), 111–119.

Bustinza, O. F., Opazo-Basaez, M., & Tarba, S. (2021). Exploring the interplay between smart manufacturing and KIBS firms in configuring product-service innovation performance. *Technovation*. In press.

Chandler, J. D., & Lusch, R. F. (2015). Service systems: A broadened framework and research agenda on value propositions, engagement, and service experience. *Journal of Service Research, 18*(1), 6–22.

Chandler, J. D., & Vargo, S. L. (2011). Contextualization and value-in-context: How context frames exchange. *Marketing Theory, 11*(1), 35–49.

Coreynen, W., Matthyssens, P., & Van Bockhaven, W. (2017). Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management, 60*, 42–53.

Corvellec, H., & Hultman, J. (2014). Managing the politics of value propositions. *Marketing Theory, 14*(4), 355–375.

Darling, P. (2011). *SME mining engineering handbook* (3rd ed.). Society for Mining, Metallurgy, and Exploration.

Dubois, A., & Gadde, L. E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research, 55*(7), 553–560.

Edvardsson, B., Kleinaltenkamp, M., Tronvoll, B., McHugh, P., & Windahl, C. (2014). Institutional logics matter when coordinating resource integration. *Marketing Theory, 14*(4), 1–19.

Eisenhardt, K. (2021). What is the Eisenhardt method, really? *Strategic Organization, 19*(1), 147–160.

Floersch, J., Longhofer, J. L., Kranke, D., & Townsend, L. (2010). Integrating thematic, grounded theory and narrative analysis. A case study of adolescent psychotropic treatment. *Qualitative Social Work, 9*(3), 407–425.

Frank, A. G., Mendes, G. H. S., Ayala, N. F., & Ghezzi, A. (2019). Servitization and industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. *Technological Forecasting and Social Change, 141*, 341–351.

Frow, P., McColl-Kennedy, J. R., Hilton, T., Davidson, A., Payne, A., & Brozovic, D. (2014). Value propositions: A service ecosystems perspective. *Marketing Theory, 14*(3), 327–351.

Gebhardt, G. F., Carpenter, G. S., & Sherry, J. F., Jr. (2006). Creating a market orientation: A longitudinal, multifirm, grounded analysis of cultural transformation. *Journal of Marketing, 70*(October), 37–55.

George, A. L., & Bennett, A. (2004). *Case studies and theory development in the social sciences*. Cambridge, MA: MIT Press.

Grubic, T., & Jennions, I. (2018). Remote monitoring technology and servitised strategies – Factors characterising the organisational application. *International Journal of Production Research, 75*, 1–17.

Gu, Y., Goez, J. C., Guajardo, M., & Wallace, S. W. (2020). Autonomous vessels: State of the art and potential opportunities in logistics. *International Transactions in Operational Research, 28*, 1706–1739.

Halinen, A., & Törnroos, J.-Å. (2005). Using case methods in the study of contemporary business networks. *Journal of Business Research, 58*(9), 1285–1297.

Hsuan, J., Jovanovic, M., & Clemente, D. H. (2021). Exploring digital servitization trajectories within product-service-software space. *International Journal of Operations & Production Management, 41*(5), 598–621 (In Press).
Huikkola, T., Kohtamäki, M., Rabetino, R., Makkonen, H., & Holtkamp, P. (2021). Overcoming the challenges of smart solution development: Co-alignment of processes, routines, and practices to manage product, service, and software integration. *Technovation*. In press.
Huikkola, T., Rabetino, R., Kohtamäki, M., & Gebauer, H. (2020). Firm boundaries in servitization: Interplay and repositioning practices. *Industrial Marketing Management, 90*, 90–105.
Iansiti, M., & Lakhani, K. R. (2014). Digital ubiquity. How connections, sensors, and data are revolutionizing business. *Harvard Business Review, 92*(11), 90–99.
Jovanovic, M., Sjödin, D., & Parida, V. (2021). Co-evolution of platform architecture, platform services, and platform governance: Expanding the platform value of industrial digital platforms. *Technovation*. In press.
Kamalaldin, A., Linde, L., Sjödin, D., & Parida, V. (2020). Transforming provider-customer relationships in digital servitization: A relational view on digitalization. *Industrial Marketing Management, 89*, 306–325.
Keränen, J., Terho, H., & Saurama, A. (2021). Three ways to sell value in B2B markets. *MIT Sloan Management Review*. In press.
Kohtamäki, M., Parida, V., Oghazi, P., Gebauer, H., & Baines, T. S. (2019). Digital servitization business models in ecosystems: A theory of the firm. *Journal of Business Research, 104*(November), 380–392.
Kohtamäki, M., Parida, V., Patel, P. C., & Gebauer, H. (2020). The relationship between digitalization and servitization: The role of servitization in capturing the financial potential of digitalization. *Technological Forecasting and Social Change, 151*.
Kowalkowski, C., Witell, L., & Gustafsson, A. (2013). Any way goes: Identifying value constellations for service infusion in SMEs. *Industrial Marketing Management, 42*, 18–30.
Lamberg, J-A., Lubinaitė, S., Ojala, J., & Tikkanen, H. (2019). The curse of agility: The Nokia Corporation and the loss of market dominance in mobile phones, 2003–2013. *Business History, 63*(4), 574–605.
Legner, C., Eymann, T., Hess, T., Matt, C., Böhmann, T., Drews, P., … Ahlemann, F. (2017). Digitalization: Opportunity and challenge for the business and information systems engineering community. *Business and Information Systems Engineering, 59*(4), 301–308.
Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills: Sage.
Linde, L., Sjödin, D., Parida, V., & Wincent, J. (2021). Dynamic capabilities for ecosystem orchestration a capability-based framework for smart city innovation initiatives. *Technological Forecasting and Social Change, 166*.
Lusch, R. F., & Nambisan, S. (2015). Service innovation: A service-dominant logic perspective. *MIS Quarterly, 39*(1), 155–175.
Maglio, P. P., & Spohrer, J. (2008). Fundamentals of service science. *Journal of the Academy of Marketing Science, 36*(1), 18–20.
Makkonen, H., Aarikka-Stenroos, L., & Olkkonen, R. (2012). Narrative approach in business network process research. Implications for theory and methodology. *Industrial Marketing Management, 41*(2), 287–299.
Makkonen, H., & Olkkonen, R. (2017). Interactive value formation in interorganizational relationships: Dynamic interchange between value co-creation, no-creation, and co-destruction. *Marketing Theory, 17*(4), 517–535.
Makkonen, H., Saarikorpi, M., & Rajala, R. (2019). A transition from goods-dominant to service-dominant exchange logic in a B2B relationship : A relationship positioning perspective. *Industrial Marketing Management, 81*, 65–77.
Meindl, B., Ayala, N. F., Mendonça, J., & Frank, A. G. (2021). The four smarts of industry 4.0: Evolution of ten years of research and future perspectives. *Technological Forecasting and Social Change, 168*.
Miles, M., & Huberman, A. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.
Möller, K., Nenonen, S., & Storbacka, K. (2020). Networks, ecosystems, fields, market systems? Making sense of the business environment. *Industrial Marketing Management, 90*, 380–399.
Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital innovation management: Reinventing innovation management research in a digital world. *MIS Quarterly, 41*(1), 223–238.
Parida, V., Sjödin, D., & Reim, W. (2019). Reviewing literature on digitalization, business model innovation, and sustainable industry: Past achievements and future promises. *Sustainability, 11*(2), 1–18.
Paschou, T., Rapaccini, M., Adrodegari, F., & Saccani, N. (2020). Digital servitization in manufacturing: A systematic literature review and research agenda. *Industrial Marketing Management, 89*, 278–292.
Patala, S., Jalkala, A., Keränen, J., Väisänen, S., Tuominen, V., & Soukka, R. (2016). Sustainable value propositions: Framework and implications for technology suppliers. *Industrial Marketing Management, 59*, 144–156.
Payne, A., Frow, P., & Eggert, A. (2017). The customer value proposition: Evolution, development, and application in marketing. *Journal of the Academy of Marketing Science, 45*, 467–489.
Pekkarinen, S., Hennala, L., Tuisku, O., Gustafsson, C., Johansson-Pajala, R.-M., Thommes, K., … Melkas, H. (2020). Embedding care robots into society and practice: Socio-technical considerations. *Futures, 122*.
Piekkari, R., Plakoyiannaki, E., & Welch, C. (2010). 'Good' case research in industrial marketing: Insights from research practice. *Industrial Marketing Management, 39*(1), 109–117.
Polova, O., & Thomas, C. (2020). How to perform collaborative servitization innovation projects: The role of servitization maturity. *Industrial Marketing Management, 90*, 231–251.
Porter, M., & Heppelmann, J. (2015). How smart, connected products are transforming companies. *Harvard Business Review, October*, 96–112.
Porter, M., & Heppelmann, J. (2017). Why every organization needs an augmented reality strategy. *Harvard Business Review, 95*(6), 46–57.
Rabetino, R., Kohtamäki, M., Lehtonen, H., & Kostama, H. (2015). Developing the concept of life-cycle service offering. *Industrial Marketing Management, 49*, 53–66.
Raddats, C., Kowalkowski, C., Benedettini, O., Burton, J., & Gebauer, H. (2019). Servitization: A contemporary thematic review of four major research streams. *Industrial Marketing Management, 83*, 207–223.
Reim, W., Sjödin, D. R., & Parida, V. (2018). Mitigating adverse customer behaviour for product-service system provision: An agency theory perspective. *Industrial Marketing Management, 74*, 150–161.
Ringbom, H. (2019). Regulating Autonomous Ships—Concepts, Challenges and Precedents. *Ocean Development & International Law, 50*(2–3), 141–169.
Rolls-Royce. (2016). *Autonomous ships – The next step*. Company brochure. Available at: https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/%20customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf.
SAE International. (2016). Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems. https://www.sae.org/standards/content/j3016_201401/.
Saidani, M., Pan, E., Kim, H., Greenlee, A., Wattonville, J., Yannou, B., Leroy, Y., & Cluzel, F. (2020). Assessing the environmental and economic sustainability of autonomous systems: A case study in the agricultural industry. *Procedia CIRP, 90*, 209–214.
Sjödin, D., Parida, V., Kohtamäki, M., & Wincent, J. (2020). An agile co-creation process for digital servitization: A micro-service innovation approach. *Journal of Business Research, 112*, 478–491.
Sjödin, D. R., Parida, V., Leksell, M., & Petrovic, A. (2018). Smart factory implementation and process innovation. *Research-Technology Management, 61*(5), 22–31.
Sklyar, A., Kowalkowski, C., Tronvoll, B., & Sörhammar, D. (2019). Organizing for digital servitization: A service ecosystem perspective. *Journal of Business Research, 104*, 450–460.
Smith, D. J. (2013). Power-by-the-hour: The role of technology in reshaping business strategy at Rolls-Royce. *Technology Analysis & Strategic Management, 25*(8), 987–1007.
Storbacka, K., & Nenonen, S. (2011). Scripting markets: From value propositions to market propositions. *Industrial Marketing Management, 40*, 255–266.
Strønen, A. (2014). *A vision of ship intelligence*. Skipsrevyen. Available at: https://www.skipsrevyen.no/article/a-vision-of-ship-intelligence/.
Thomson, L., Kamalaldin, A., & Sjödin, D. (2021). A maturity framework for autonomous solutions in manufacturing firms: The interplay of technology, ecosystem, and business model. *The International Entrepreneurship and Management Journal, 18*, 125–152.
To, K. M., Chau, K. P., & Kan, C. W. (2020). The logic of innovative value proposition: A schema for characterizing and predicting business model evolution. *Journal of Business Research, 112*, 502–520.
Töytäri, P., Turunen, T., Klein, M., Eloranta, V., Biehl, S., & Rajala, R. (2018). Aligning the mindset and capabilities within a business network for successful adoption of smart services. *Journal of Product Innovation Management, 35*(5), 763–779.
Tronvoll, B., Sklyar, A., Sörhammar, D., & Kowalkowski, C. (2020). Transformational shifts through digital servitization. *Industrial Marketing Management, 89*, 293–305.
Tuli, K., Kohli, A., & Bharadwaj, S. G. (2007). Rethinking customer solutions: From product bundles to relational processes. *Journal of Marketing, 71*(3), 1–17.
Ulaga, W., & Reinartz, W. J. (2011). Hybrid offerings: How manufacturing firms combine goods and services successfully. *Journal of Marketing, 75*(November), 5–23.
Vargo, S. L., & Akaka, M. A. (2012). Value co-creation and service systems (re)formation: A service ecosystems view. *Service Science, 4*(3), 207–217.
Vargo, S. L., & Lusch, R. F. (2004). Evolving to a new dominant logic for marketing. *Journal of Marketing, 68*(1), 1–17.
Vargo, S. L., & Lusch, R. F. (2011). It's all B2B… and beyond: Toward a systems perspective of the market. *Industrial Marketing Management, 40*(2), 181–187.
Vargo, S. L., & Lusch, R. F. (2016). Institutions and axioms: An extension and update of service-dominant logic. *Journal of the Academy of Marketing Science, 44*(1), 5–23.
Vendrell-Herrero, F., Bustinza, O. F., Parry, G., & Georgantzis, N. (2017). Servitization, digitization and supply chain interdependency. *Industrial Marketing Management, 60*, 69–81.
Wilkinson, A., Dainty, A., & Neely, A. (2009). Changing times and changing timescales: The servitization of manufacturing. *International Journal of Operations & Production Management, 29*(5).
Woodside, A. G., & Wilson, E. J. (2003). Case study research methods for theory building. *The Journal of Business and Industrial Marketing, 16*(6/7), 493–508.