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Design and Implementation of a Systematic Product-Service System Innovative Framework: A Case Study

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Abstract
The objective of the study is to create a product-service system (PSS) innovative framework that aligns with a case company's strategy, competencies, and strengths. First, this study shows that the case company's Design Thinking Macro process and PSS fundamentals might serve as the foundation of a suitable PSS innovative framework for the company's upcoming service. Second, it serves as a descriptive stat-of-the-art study – the study investigates the case company's innovation potential and potential for controlling hazards in the direction of servitization. The study aims to understand the current state of the case company and assist it in becoming a more flexible PSS supplier. The results show that the case company is committed to advance a cross-organizational development plan to strengthen its PSSs to capitalize in servitization. Because of its end-to-end capabilities, scientific innovation, and value-adding products that have a tangible component of value, the company's product portfolio is well-positioned in terms of servitization.

Keywords
Product-service systems (PSS), Design Thinking, innovation process, servitization, rapid prototyping.

Introduction

Product-service systems (PSS) may accommodate the different needs and preferences of stakeholders by providing a range of values in a service-dominant way. Tightly connected service and product components make up a typical PSS. PSS-based business strategies create a value proposition that is centered on the needs of end users rather than the product (Annarelli et al., 2016; Ren and Zheng, 2024). This makes it easier to design a need-fulfillment system with significantly fewer negative effects on the environment and socjety (Moro et al., 2022). According to (De Zan et al. (2015), product design and production are no longer the only ways for compaies to obtain a competitive edge and set themselves apart; product-service integrated solutions also offer the possibility of innovation and enhance the whole offering. This could be as easy as adding more services to the product range to increase its usefulness and life cycle over time (for a more sustainable performance) and to give clients a better positive experience that warrants additional income (Roy and Cheruvu, 2009; Trevisan and Brissaud, 2017; Paliyenko et al., 2023).

Manufacturers are becoming more and more focused on providing additional services or servitizing existing products (Baines et al., 2007; Annarelli et al., 2019). The process of creating income streams for manufacturers by offering services is known as "servitization" (Ellram, 1993; Kindström, 2010; Oliva and Kallenberg, 2003; Tukker, 2004). For many manufacturers working in the business-to-business (B2B) context, which is the subject of this study, servitization has become a widespread trend (Meier et al., 2010). To understand the range of novel servitization strategies, this study goes over the essential components of PSS design and Design Thinking procedures. The study develops a field to create an innovative product-service system (PSS) that supports a case company's strengths, skills, and strategic business development in an emerging offering.

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To give this study a more practical viewpoint, the research attempts to develop a PSS innovative framework and apply it as an example in the business-to-business (B2B) energy supply and demand sector. Some growth industries propelled by megatrends are renewable energy, autos, and smart cities. Differentiation in this domain comes from expert measurements to digital insights that enable decision-making and integrating these collections of outcome-driven services with a wide range of hardware options. New proficiencies and capabilities in servitization, PSS, and agile development, including Design Thinking techniques, are needed to utilize these decision-supporting digital insights (Zheng et al., 2018).

Study Background

This study develops a PSS innovative framework and practices it in a case company's B2B energy supply and demand sector, specifically in district heating generation and distribution systems. In pursuit of developing a framework, multi-method qualitative and quantitative research was used. The research employs a qualitative and normative methodology. Moreover, the study explores new service-oriented solution patterns that fit customer references in the case company. The study supports the organization contributing and growing in terms of society's transition towards customer complexity and sustainability (Raddats et al., 2016). The study portfolio represents an opportunity to capitalize on potential value-added activities and value communication opportunities through the PSS framework.

The case company, a well-established deep-tech engineering firm with strong credentials and experience in developing electronics gear, is the subject of the study. Maintaining long-term market leadership and entering new areas with room for expansion are two aspects of its approach. The plan also calls for the servitization of business in developing and expanding regions and the introduction of new recurring revenue streams. The case study is carried out in the field of energy supply, more precisely in the generation and distribution of district heating. The study examines the case company's motivations, both internal and external, regarding PSS, the servitization subcategory, as a descriptive 'current state' study. Better understanding of the organization's current state will help the business become an agile PSS producer.

Study Aims and Research Questions

The studied case company is currently undergoing a significant strategic transformation in support of its PSS offerings. Consistency in PSS solutions, marketing, production, and selling customized bundles are significant challenges to many companies, including the case company. This necessitates exploring the company's capabilities and weaknesses in terms of servitization, which aims to increase understanding of the company's current situation, thus enabling the company to transition into an agile PSS producer. Pitfalls regarding servitization include the company's unclear processes for customer information, lack of?daily customer information flow, and in terms of the transparency of the service offering's cost structure (Kurtz et al., 2023; Kennedy and Rabbirai, 2024). Therefore, understanding the company's current state and establishing a framework for innovative PSS to support emerging offerings is necessary. Based on the case company's needs, this study identifies two research questions (RQs), which can be stated as follows:

RQ 1: What is the status of servitization in the case company's existing business?

RQ 2: What would be a suitable PSS innovative framework to improve the servitization of the case company's emergent offerings?

The first research question is intended to assist the case company in identifying potential success factors and pitfalls associated with the transition to decision-supporting digital insights and result-driven service bundles. The scope of the second research question is to develop a workable PSS innovative framework to support the case company's emerging service offerings.

The remaining part of the article is organized as follows: Section 2 outlines the theoretical framework, explaining the PSS, customer, Design Thinking, and rapid prototyping. Section 3 outlines the study methodology, while Section 4 presents a brief description of the studied case company. The overall study results are presented and discussed in Section 5. The study outcomes are concluded with limitations and future work in Section 6.

Literature review

Concept of Servitization

A corporation that is product-oriented will become product/service-oriented due to the trend towards servitization (Baines et al., 2007; Sousa and da Silveira, 2019). Manufacturing businesses have always created and manufactured real goods to meet the needs of customers. Companies may also provide maintenance, instruction, and repair services for their clients to address their basic needs in the event of malfunctions and usage issues. Historically, the company's strategy has not placed much emphasis on these product-

oriented services (Lay et al., 2009; Lafuente et al., 2023; Sgambaro et al., 2024). Manufacturers mostly provide sophisticated engineering items, apply servitization tactics, and include a mention of this in their plans (Neely et al., 2011). (Neely et al. (2011) summarize the strategy shifts in five categories: (1) components to environments, (2) results to outcomes, (3) vendors to strategic partners, (4) interactions to connections, and (5) goods to services.

The shift in a company's business model from one that is centered on products or services to one that is based on a combination of products, services, and integrated systems is known as "business servitization" (Annarelli et al., 2019). In the 1980s, the word "servitization" initially surfaced (Vandermerwe and Rada, 1988). There are many benefits that come with servitization for manufacturers. First, it can offer advantages over rivals that help set the business apart. Second, it might lead to monetary benefits such as increased revenue. Lastly, it might offer benefits specific to marketing, such as improving client relationships (Oliva and Kallenberg, 2003; Brax, 2005; Baines et al., 2007; Fang et al., 2008; Sgambaro et al., 2024). Moreover, benefits can be obtained through consistent income and predictable long-tail revenue (Meier et al., 2010; Annarelli et al., 2019).

Raddats et al. (2016) state that clients of manufacturing organizations embrace full-stack solutions for three reasons: improving customer value, improving service quality, and moving capital expenditure from capital expenditures, or CAPEX, to operating expenses, or OPEX investment. A business's major long-term investments are known as CAPEX. Daily costs incurred to keep a business operating are known as OPEX (Ross, 2021).

Concept of Product Service Systems (PSS)

PSS, which is a subcategory of servitization, is an integrated combination of products and services to better fulfil customer needs and achieve environmental benefits (Manzini and Vezzoli, 2003). This emerged in the 1990s to define the PSS concept (Brax, 2005; Baines et al., 2007). Definitions in the literature vary considerably, particularly concerning the environmental factor. The definitions emphasize the importance of bundling the service and product as a complete system and customer-centricity. However, even with the variations, ecological benefits are generally desired while designing PSS.

According to Goedkoop et al. (1999), "A Product Service Systems (PSS) is a marketable set of products and services capable of jointly fulfilling a user's need. The PSS system is provided either by a single company or by an alliance of companies. It can enclose products (or just one) and additional services. Furthermore, product and service can be equally important for function fulfilment". According to (Bauren et al. (2013), the most cited definitions of PSS are by Baines et al. (2007) and Mont (2002). Baines et al. (2007) state that "A PSS is an integrated product and service offering that delivers value in use. A PSS offers the opportunity to decouple economic success from material consumption and hence reduce the environmental impact of economic activity". Similarly, Mont (2002) reasons that PPS should be defined as "A system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models".

The trend towards servitization means a shift from a product-oriented company to a product/service-oriented company (Baines et al., 2007). Traditionally, companies in the manufacturing industry develop and produce tangible products to satisfy consumers' needs. In addition, companies may offer customers maintenance, training, and repair services to answer the essential requirements in case of malfunction and usage problems. These product-oriented services have not traditionally played an influential role in the company's strategy in the past (Lay et al., 2009). According to Neely et al. (2011), manufacturers primarily offer complex engineering products, implement servitization strategies, and consider these products within their business strategies.

Concept of Design Thinking

Design Thinking has progressed from its academic roots in the 1980s to attain a broad audience in the corporate, entrepreneurial, business community (Brown, 2008) and beyond. Design Thinking is a creative process with analytical perspectives that allows people to experiment, create through doing and prototyping, and gain customer feedback and iteration. Design Thinking acknowledges that a particular intuition and analytical approach are critical for innovative solutions (Razzouk and Shute, 2012). The basic steps of Design Thinking are emphasized as define, ideate, prototype, and test.

According to IDEO (2021), "Design Thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success". In simple words, Design Thinking is a discipline that matches customers' desires, acknowledging technological feasibility, customer references and values, and what viable business strategy can renovate in the market opportunity (Björklund et al., 2019; Kimbell, 2011).

Desirability, viability, and feasibility are achieved using the designer's sensibility and methods to understand customer needs and the solution domain. Leading Fortune 500 companies are nowadays ranked in terms of the most innovative companies investigating ways to incorporate a Design Thinking approach into each operational phase (Brown and Wyatt, 2010; Forbes, 2018; Fortune, 2021). According to Rae (2016), when design principles are applied to strategy and innovation, the innovation success rate increases considerably. Apple, Pepsi, IBM, Nike, Procter and Gamble, and SAP have all outpaced the SandP 500 by an astounding 211 per cent during a ten-year period and are companies of design-led status.

In the Design Thinking approach, the role of prototyping is essential. Liu's (2016) double diamond framework includes the macro process of rapid prototyping inside the solution phase. The goal of prototyping is to build a functional prototype for presentation to the tester and to examine the function(s) that the project wants to validate (Björklund et al., 2019; Mattern, 2019). The prototype projects are large, and the prototypes are needed to validate with different aspects or goals. Due to the variation of the prototype processes, they need to validate at different clarity levels such as diverge vs. converge, and functionalities (Schori, 2021).

Materials & Methods

Method for Evaluating Current State of Service Business

As shown in Mourtzis et al. (2016), questionnaires are the most used method to assess servitization, and this study uses it as a baseline. Multiple academic studies on PSS transformation have emphasized the critical nature of strategic alignment between the service transition strategy and PSS structural elements (Gebauer et al., 2005; Kindström, 2010; Adrodegari and Saccani, 2017). However, it is hard to find a comprehensive framework that demonstrates the company's intention to align its current internal capabilities with its external threats (Baines et al., 2007; Meier et al., 2010). The framework proposed by (Sholihah et al. (2019) incorporates these factors, and results in a comprehensive questionnaire, which is also used in this study for evaluating the drivers of servitization in the manufacturing industry. The research formed a questionnaire to analyse the company's internal capabilities and external forces on servitization. The questionnaire set has been modified to reflect case company's terminology and methods of operations.

The suggested framework extends the scope of the initial SWOT analysis by including essential competencies of the serviced business and the Business Model Environment framework to create structured assessment questions for internal and external analysis, respectively. The SWOT analysis iscarried out in organizations to minimize uncertainties and risks. This tool compares the manufacturer's present business with the desired capabilities and takes the necessary initiatives to fulfill any insufficient capabilities.

Execution of Current State Study

In this study, the number of interviewees was determined during the Covid-19 pandemic. In these interviews, the questions were complex, and internal experts answered them. The study employs a diverse range of responders to effect a varied range of responses. According to Nguyen (2015) and DeJonckheere and Vaughn (2019), open field together with a set of questions are a suitable method to (1) gather qualitative, open-ended data; (2) explore participant ideas, feelings, and beliefs about a particular topic; and (3) dive deeply into personal and occasionally sensitive, matters. This is why it is utilized to broaden the scope of the study, extending the Sholihah et al. (2019) framework.

An online survey was conducted for the 'current state' study. For this purpose, an online form was created with the MS Forms tool. The survey was sent via email to select participants. An open field was also left for participants to explain their answers more fully.

Online Survey

In total 14 respondents were selected from the case company based on their long experience in various departments related to servitization. The corresponding roles and departments of the respondents are presented in Table 1. Table 1 shows that the respondents have various positions in the case company along with their corresponding departments. The aim of selecting the respondents with various roles and departments was to foster diversity in the responses. The respondents answered the survey questions on a scale from zero to ten, with zero being the lowest and ten the highest value.

SWOT-Analysis

A SWOT analysis is designed to assist in conducting a realistic, fact-based, data-driven examination of the strengths and weaknesses of an organization, initiative, or industry (Leigh, 2010; Satta et al., 2021). The company must ensure accuracy by eliminating preconceived conceptions or grey zones in favor of real-world scenarios. SWOT analysis is used in this study

Table 1
Survey respondents for online survey

Role	Department
Product Manager	Product and Technologies
Product Area Orchestrator	Product and Technologies
Vice President, P and T	Product and Technologies
Offering Manager	Technology vertical
Section Head	New Growth Markets
Product Manager	Technology vertical
Section Head	New Growth Markets
Business Development Manager	Product and Technologies
Service Product Manager	Project and Customer Services
R and D Manager	Product and Technologies
Head of Portfolio	Product and Technologies
Head of Ground Transportation Strategy and Business Development.	Strategy and Business Development
Global Solution Manager	Platforms and API's
Projects and Customer Services, NOC Manager North America	Project and Customer Services

to structure and understand the conclusions on the current state of the company with the goal of situation analysis. The problems are complex, real-life problems with various gray areas, so the frameworks present an excellent structure for the analysis.

Workshop Sprints

The PSS innovative framework was validated through its execution in part during an intensive workshop sprint. A multidisciplinary team from product management, design, sales, and marketing participated in the workshop. Multidisciplinary teams foster a diversity of perspectives, resulting in positive conflict and improved outcomes. A design area was required to conduct the innovation workshops. The design area was specified through external interviews with district heating industry professionals and internal discussions with the study steering group. The following workshops were held:

Workshop 1 – Problem statement and problem area exploration

Workshop 2 – Product vision and further ideation

Workshop 3 – Prototype ideation and validation

Workshop 4 – External prototype testing with customer

Workshop 5 – Customer feedback-driven iteration

Energy Sector Case Study

The energy sector case study was completed with external interviews in three energy supply companies, conducting business in energy generation and district heating. Additionally, two providers of distributed energy resource (DER) optimization software were involved in the study. The companies were Scandinavia-based, representing the cutting edge of clean energy production in their sectors. The case study was needed to conduct the validation process during the innovation workshops of the PSS innovative process. The semi-structured interviews focused on forming a comprehensive design area to give the study a more pragmatic point of view. The background of the participants for the external semi-structured interviews is presented in Table 2.

Table 2
Background of the participants in the external semi-structured interview

Role	Organization
Data Scientist	Energy Company A
Digital Transformation Leader	Energy Company B
Production manager	Energy Company C
Senior Data Scientist	DER optimization company A
Product Manager	DER optimization company B
Head of Sales and Marketing	DER optimisation company B

Description of the case company

The case company updated its business objectives for 2024, increasing the target for growth and sharpening its vision. In the organization's updated business objectives, the case company's adjusted focus is to sustain long-term market leadership and expand to new markets with growth opportunities. Renewable energy, automotive, and smart cities are all examples of these megatrend-driven growth industries. New differentiation in this market comes from professional-grade (previously only reference grade) hardware for decision-supporting digital insights and combining result-driven service bundles with a diverse hardware selection.

The case company is transforming into a service company, and the strategic changes described appear in the organization's day-to-day operations. The transformation to supporting recurring revenue business, platforms, services, and other critical functions are in transition and under development. These service aspects, including decision-supporting digital insights, will necessitate the development of new skills and capabilities in servitization, PSS, and agile development methodologies such as Design Thinking. In this field, a current state and PSS innovative framework is desired.

The case company is traditionally a hardware-focused company whereby most of the services it provides are inextricably related to its hardware sales and could even be considered hardware features (e.g., calibration services, warranty). These services can be viewed as product-centric services. Additionally, the case company provides customer value and profit-focused services on top of product-centric services, such as digital services (e.g., decision support services) and use-oriented services (e.g., remote monitoring). Services represent a relatively small part of the company, historically serving as a support function supporting hardware sales.

Nevertheless, the case company's strategy is to transform itself partly into a recurring revenue business, focused on supporting decision-making, actionable insights, value-based solutions, and services with higher margins such as monitoring services. The case company's strategy also emphasizes project services, encompassing all aspects of a project: for example, installation and acceptance testing. Consultative services include, but are not limited to, site surveys and training. The case company's growing services with ambitious growth goals include continuous monitoring systems, maintenance contracts, and digital services, on which this study focuses.

Results analysis

Internal Online Survey

Radar diagrams and charts illustrate the deviation of internal capabilities and external forces of the responses. The radar diagrams include graphs divided on an area and topic basis. The charts show the case company's identified internal capabilities at the average question level. Standard deviation is also visualized to demonstrate differentiating opinions in the organization. The average responses were 5.90 in internal capabilities, putting it slightly on the positive side of the scale. The average value for external force was 6.02.

Internal Capabilities

The results of the internal capabilities online questionnaire are listed in Table 3, along with a breakdown by area, topic, and question. The scores are calculated by averaging the responses to the questions. After the results, a descriptive analysis of the results is conducted.

External Forces

The external forces online questionnaire's results are listed in Table 4, along with a breakdown by area and question. The average responses to questions are used to calculate the scores. After the results are obtained, a descriptive analysis of the data is performed.

Designing a Suitable Product-Service System Innovation Framework

The framework is based on Design Thinking principles and PSS characteristics and was field-tested in part using Design Thinking tools during workshop sprints. The framework can be used in conjunction with other toolsets and various product phases. The proposed PSS innovative framework (Fig. 1) designed for this study is based on the New Double Diamond Model of Design Thinking (Liu, 2016), the Design Thinking macro process (University of St. Gallen, 2021), and PSS characteristics (Baines et al., 2007; Kindström, 2010; Lay, 2014; Lay et al., 2009).

A concept, idea, vision, or objective for a new product, service, or feature triggers the process. While the result may vary, it should be a viable, feasible, and desirable solution. More precisely, the trigger requires the organization to begin mentally associating the technologies, systems, techniques, and processes that are feasible or accessible with how they can be used to address unmet customer requirements.

Table 3
Results of internal capabilities in the online survey

Area	Avg. value	Topic	Avg. value	Question	
Financial	5.27	Value-based pricing strategy	5.54	Shareholder value	5.21
				Revenue from product sale	6.36
				Additional revenue from service	5.36
				New revenue from new customer	5.21
		Efficient cost structure	4.75	Cost structure	4.21
				Operation cost	5.29
Customer	6.37	Customer intimacy	6.37	Value proposition	6.21
				Relationship with customer	6.93
				Company image	5.00
				Customer satisfaction	7.79
				Customer acquisition	5.93
Internal business	6.25	Product service co-creation with the customer	6.32	Product/service innovation	5.29
				Customer relationship	7.36
		Collaboration with partner	6.39	Close collaboration with the partner companies	6.21
				Distribution channel within partners	6.57
		Efficient and effective distribution channel	6.04	Effective service provision	5.43
				Operation	6.64
Learning and Growth	5.82	Service-oriented personnel	6.61	Service capability	6.43
				Training	6.79
		Service-oriented ICT	5.54	Knowledge management	4.57
				CRM system	6.50
		Service-oriented performance measurement system	4.57	Service-oriented bonus structure	4.57
		Product service culture	5.93	Cross-functional team	5.93
				Organization alignment	5.93

Table 4
Results of external forces in the online survey

Area	Avg value	Question	Avg value
Industry forces	6.23	Competitor	5.64
		New entrants	7.00
		Substitute product or service	6.21
		Bargaining power of suppliers	5.57
		Bargaining power of buyers	6.71
Key trends	7.00	Technology trends	6.36
		Regulatory trends	7.36
		Megatrends	7.64
		Socioeconomic trends	6.64
Market forces	5.82	Market issues	5.15
		Market segments	6.21
		Needs and demands	5.14
		Switching cost	7.07
		Revenue attractiveness	5.50
Macroeconomic Forces	5.25	Global market conditions	4.71
		Capital markets	5.79
		Commodities and other resources	4.54
		Human resources	5.08
		Economic infrastructure	6.14

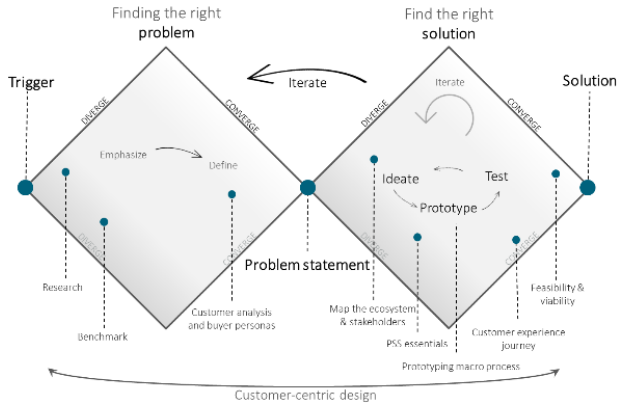

Fig. 1. Product-service-system innovation framework (adapted from Liu, 2016)

The basic differences between the proposed PSS innovative framework and Liu's (2016) are that the proposed framework identifies the needs of exclusive research, benchmark and customer analysis, and buyer personas. Without basic research it would not be possible to find the right problem, which is the key to working towards a solution. After conducting the basic research, it is necessary to benchmark the identified problems with respect to potential solutions. In the case of finding the right solution, the final stage considered in this new framework is to conduct customer analysis and buyer personas. In this phase, the overall needs of the customers as well as buyer personas are studied and considered carefully to find out if there are any problems.

On the other hand, in the case of finding the right solution, this proposed framework also differs from the framework proposed by Liu, (2016), by adding a map of the ecosystem and stakeholders, PSS essentials, prototyping macro process, customer experience journey, and feasibility and validity. To find the right solution for the case company, it is necessary to map the possible solutions with the existing ecosystem and stakeholders who are the direct beneficiaries of the solutions. Additionally, product-service systems are essential and also need to be considered for a better solution. It is also necessary to prototype the macro process to obtain detailed solutions. Moreover, the customer experience journey is crucial to know the ins and outs of a customer before proceeding towards a solution. Furthermore, feasibility and viability studies also need to be carried out before arriving at a solution to the company. In any potential solution, a company should conduct a feasibility as well as a viability study to make the solution much more concrete and sustainable.

Finding the Right Problem

The "finding the right problem" phase highlights the issue and better understands the customer's pain points and experiences. This phase is designed to foster an empathic understanding of the subject or situation at hand. Empathy is critical to a human-centered design process because it enables designers to put their personal beliefs and assumptions aside to gain insight into customer functions and needs. Through a variety of customer-centric activities, it is possible to gain an understanding of the fundamental issue. The activities illustrated in Fig. 1 support defining the problem, such as research, benchmarking, customer analysis, and buyer personas. The necessary processes must be developed in close collaboration with the customer to ensure a customer-centric understanding of the need. The objective of this first diamond is to have 1–3 problem statements that the design group understands and agrees on.

Finding the Right Solution

When the problem statement is defined, the design team enters the "finding the right solutions" phase. However, iteration allows for a constant transformation of the problem statement, if necessary. This phase is based on innovation, ideation, gaining detailed knowledge, hands-on prototyping, and iteration. The phase of mapping the ecosystem and stakeholders directs the design team towards understanding the relevant stakeholders regarding the design problem. The ecosystem mapping focuses on understanding the stakeholders and deepening understanding of what the ecosystem members can provide back to the stakeholders. The PSS innovative is centered on collaboration, with each ecosystem member contributing their unique strengths. The design can leverage this shared knowledge base to improve the solution design.

Learnings from the Workshops

Testing and validation of the proposed innovation framework was performed through a design sprint in five workshops. The first workshop began with an overview of the PSS innovative and design area. The design area was researched and defined at external interviews and covered the PSS innovative framework's first phase: "finding the right problem". The design area is as follows:

1. Weather station detecting the key present weather parameters
2. Hyper-local weather and environment forecasts (APIs)
3. Ability to improve hyper-local forecasting with local weather stations
4. SaaS platform – User Interface

Workshop 1 – Problem Statement and Problem Area Exploration

The problem statement was written in the following format: How might we [what: goal] so that [who: stakeholder] can [why: need/insight]? This exercise aimed to identify areas for improvement to design new PSSs instead of separate services and hardware. The journey reveals the complexity of the current offer. Additionally, the design group mapped ecosystem members to identify the problem statement and explore the problem area.

After ecosystem mapping, the design group shifted to the first round of ideation by brainstorming new ideas using a tool called "reverse brainstorming". The objective of "reverse brainstorming" is to generate as many ideas as possible without knowledge about the quantity over quality of the ideas. Reverse brainstorming works by utilizing the previously formed HMW-question and determining how to escalate the problem: in other words, how to make customer problems even bigger. Finally, negative ideas generated are transformed into positive ones, resulting in ideas that add value to the customer and generate customer value. The tool and the resulting image are depicted in Fig. 2.

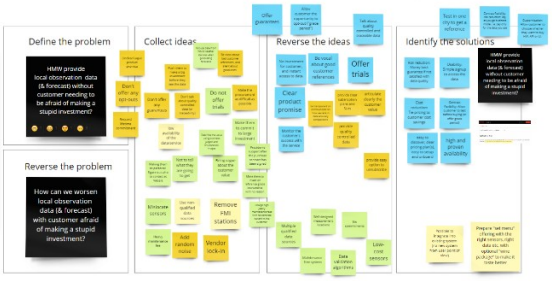

Fig. 2. Ideation tool: reverse brainstorming

Workshop 2 – Product Vision and Further Ideation

During the second workshop, the design group formed a product vision and further ideation to converge on the idea further, establish common ground, and agree on a prototype concept. Product vision is in the form: For [target customer] who [statement of need or opportunity] the [product name] is a [product category] that [key benefit, reason to buy] unlike [primary competitive alternative] our product [statement of primary differentiation]. Fig. 3 illustrates the design group's product vision.

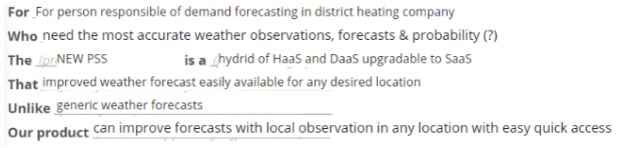

Fig. 3. Product vision formed in the second workshop

The ideation process continues in PSS essentials in the following step from the PSS innovative framework. During this phase, the design team is pressured to reorganize their thinking around the PSS fundamentals by using a PSS cheat sheet, PSS cards, and forms of customer value. The group determined the following parameters:

- Ownership during the phase of use: equipment manufacturer
- Ownership after phase of use: equipment manufacturers
- Personnel to manufacture the equipment: the case company
- Personnel to maintain the equipment: the case company or operating joint venture (3rd party)
- Operation is a parallel operation for multiple customers
- Location of operation is at the customer's establishment (the customer provides the location for instruments)
- Pricing is a combination of tiered pricing and per device pricing
- Packages are divided into (1) Weather API, including the historical data, (2) Web Application, and (3) Forecast enhanced.
- Key customer value is enhanced accuracy in local settings, instant access, and maintenance-free service
- KPIs are focused on data quality and availability

Workshop 3: Prototype Ideation and Validation

The prototype is designed as a cartoon sketch that illustrates each stage of the customer experience journey. The design group chose the prototype to be in the form of a "critical function prototype". The prototyping process is represented in Fig. 4, from diverging prototype concepts to broad customer journeys to converging on critical assumptions and creating a final prototype for testing. The design team iterates to establish a shared understanding of the concept and essential functions of the prototype.

The team created a prototype sketch to help form the opening set of assumptions (Table 5). The deck of assumptions is scored to focus the prototype on topics that need more attention. The "×" marks the

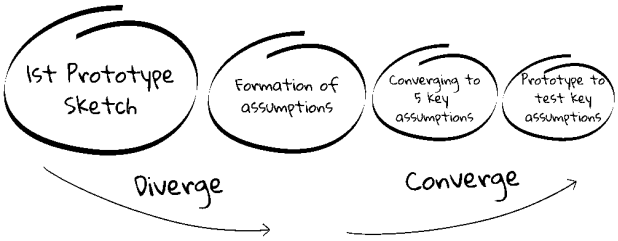

Fig. 4. Prototyping journey

five chosen assumptions in Table 5. The final prototype (Fig. 5) tests these five key assumptions with an energy sector customer.

Table 5
Prototype assumptions

	Assumption	Key's
A1	When we offer APIs, "Web Application," and "Local Enhanced Solution," the customer is interested in the last one.	×
A2	The target customer searches for this type of solution via the web, and "forecasting accuracy" or "demand forecasting weather" is what gets their attention.	
A3	15% of accuracy improvement (in RMSE) matters.	×
A4	The customer believes in the cost savings/value represented by the case company's calculators.	
A5	Customers can provide an installation site that is suited for gathering data through the product lifecycle.	×
A6	The customer wants the case company to handle the installation to make sure of the right functionality.	×
A7	There is a team that needs to identify the need for this service jointly.	
A8	The case company has access to data and can use it to improve its services.	×
A9	There is a need for probabilistic weather data	
A10	Dynamic, actionable alerting is something customers would be interested in.	
A11	No maintenance is something the customer values.	

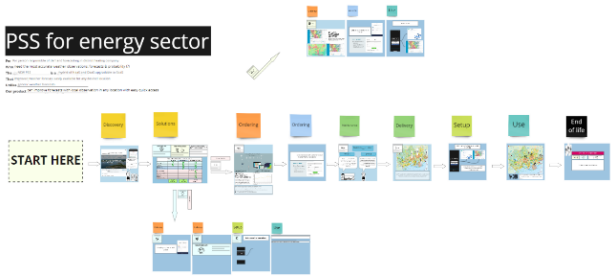

Fig. 5. PSS protype for the energy sector

Workshop 4: External Prototype Testing with Customer

This workshop introduced testing of the external prototype, which was validated with a customer from a company that generates energy and distributes district heating. The company representative observed the prototype phase-by-phase and openly commented on anything that resonated with him. The test was conducted via Zoom. In the beginning, the following instructions were given:

"I will share my screen and show frame by frame the customer journey the case company is offering. The prototype is aimed at district heating customers. Please think aloud as much as possible: what you see, the thoughts and questions that arise. In general, state whatever comes to mind as plainly as possible. There is no right or wrong in this case".

The feedback was gathered to help us better understand the customer, which is populated in Table 6. In the beginning, the customer concentrated on the location where relevant data should be shared. They mentioned that LinkedIn postings generate most of the company's technology leads. Because the company uses Weather APIs in their solutions already, the "Local Enhanced Solutions" stimulates their interest primarily.

The customer stated that accuracy is the primary value. They base their business on district heating solutions. The customer would be interested in reading a white paper or something similar in advance about improving forecasting accuracy. If pricing were based on some form of value-based pricing or risk sharing, the customer would have an easier time making a purchase decision. Additionally, some form of agile trialing would help spark interest. The trial should focus on the length of the heating season to validate the potential for improvement.

The test subject was uncertain as to whether our company could deliver the facilities/location to the equipment but was more secure about wanting the case company to handle the installation and maintenance. While data ownership is something to discuss further, the participant does not see it as a barrier to progress now.

Workshop 5 – Customer Feedback-Driven Iteration

Workshop 5 focused on customer-driven iteration which is visualized in Fig. 6. Fig. 6 shows that in this iteration the idea of the new prototype is beginning. The prototyping testing and results were shared and analyzed in the design group to further develop the new PSS concept.

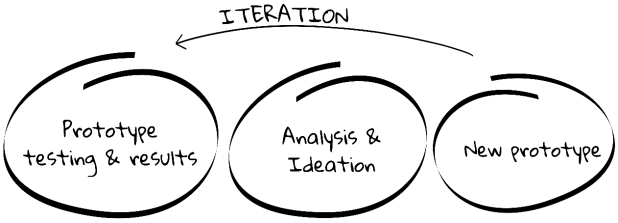

Fig. 6. Customer feedback

During the interview, the customer raised the topic of result-oriented pricing and agile trialing. Brainwriting was used to improve the presented topics in the prototype. Brainwriting is a technique that reinforces brainstorming. It is a technique for rapidly generating ideas and layering them on top of one another. Each participant jots down their responses to a question or problem. When they are finished, they pass their topic to the next person, who reviews and expands on the ideas. This study does not analyze the iteration results, but the central message is to remember to iterate, fail, and fail forward. The next step after iteration would be new prototypes.

Applicability of the Proposed PSS Innovative Framework for Companies

Two useful contributions are made by this study. To start with, it shows how managers can create a PSS, or what factors they should consider while employing design thinking techniques. Second, it gives additional organizations vital information about the kinds of difficulties they can encounter during this process, enabling them to make the necessary preparations.

The importance of strategic synchronization between the proposed PSS framework components and the service changeover strategies has been highlighted in this study. Finding a thorough framework that illustrates a company's goal to match its current internal capabilities with its external threats is challenging.

Table 6
Customer insights from the prototype

Assumption	Customer feedback
When we offer APIs, "Web Application," and "Local Enhanced Solution," the customer is interested in the last one.	When I read this, the first thing that struck me was the column on the far right (Local Enhanced Solutions). It seems to be something new. Especially exciting topics are enhanced forecast, local observations, and maintenance-free. On the left, the API is "business as usual" and seems to be a traditional API, like the one we use currently. The web application does not resonate directly, and is not particularly relevant. Control and production optimization work automatically with the power of machines. Nice, but not essential.
15% accuracy improvement (in RMSE) matters.	Accuracy is a key-value on which value is built in such solutions – taking the local differences into account more closely in load forecasting, optimizing production, and running the grid benefits an energy company has in mind when hearing such stuff. In detail, we are trying to achieve a smaller RMSE. If we achieve a 15% improvement in the RMSE, we are talking about saving a 6-figure sum per year in a city the size of ours. The prototype does not answer whether the new solution is model-based or another kind of forecast. The graph would need definitions, such as time horizon. I would like to have a white paper about the accuracy and relevant topics, maybe an example from a similar city to ours.
Customers can provide an installation site that is suited for gathering data through the product lifecycle.	I cannot say directly whether our company can deliver the facilities/location to the device. However, our company has many properties all over the city. It may be possible, I am not at all against the idea, but it should be clarified. It is preferable to plan the matter collaboratively, where the service provider would provide specific information about which physical locations are optimal for obtaining the desired installation conditions.
The customer wants the case company to handle the installation to make sure of right functionality.	We would want the case company to install the equipment. These are the things for which 101% percent confidence is desired. We want the highest possible confidence in forecasts and measurements.
The case company has access to data and can use it to improve its services.	In that sense, we probably do not mind that the weather data is developing something for someone else. The equipment would be, after all, at thease company's stations. District heating is local, so there is no direct benefit for competitors in the improved forecast. In principle, the electricity side would have the advantage of having better weather forecasts than the competitors.

These criteria are considered by the proposed framework, which produces a thorough understanding of services in this investigation.

The proposed framework is suggested for companies assessing servitization drivers in the industrial sector. To examine internal capabilities and external influences on the driving servitization in manufacturing organizations, the investigation was developed to incorporate companies' operational procedures. To provide organized evaluation for companies' internal and external analysis, the proposed framework expands the scope of the original operational analysis by incorporating the critical capabilities of the serviced companies. Such analysis is structured and quantified to reduce ambiguity and erroneous guidance. This method enables the creation of future study to address the inadequate capacities of the serviced companies by comparing the company's current business with the desired capabilities.

Discussions, conclusions and future work

The purpose of this study was to design an innovative PSS framework for a case company's emergent business and obtain thorough knowledge of internal and external capabilities towards servitization to assist the case company in determining how to improve its capabilities to develop new services that generate

demand and prosperity. Based on the identified second research question, this study demonstrated that a suitable PSS innovative framework for the case company's emergent offering could be based on the New Double Diamond Model of Design Thinking (Liu, 2016), the Design Thinking macro process (University of St. Gallen, 2021), and PSS characteristics (Baines et al., 2007; Kindström, 2010; Lay, 2014; Lay et al., 2009). The framework process starts with a concept, idea, vision, or goal for a new product, service, or feature. The solution is intended to be viable, feasible, and desirable. The process triggers the organization to conceptually link the available technology, systems, techniques, and procedures with unmeet customer needs.

The purpose of the "find the right problem" phase is to draw attention to the issue and better understand the customer's pain points and experiences. The "finding the right solution" phase involves ideation, brainstorming, acquiring extensive knowledge, prototyping hand-on methods, and iteration. In conclusion, a new PSS innovative framework is presented that integrates the empirical findings with prior literature on PSS and Design Thinking. The case study demonstrated its applicability in district load forecasting in the manufacturing business context.

The new framework is intended to be a generic framework that can be applied to any business that requires integrating tangible elements and service bundles. The primary benefit of the new framework is that it is universally applicable, despite its origins in the manufacturing business, while still providing a better understanding of PSS innovative in the service business context. The outcome revealed that the organization could use a systematic technique to innovate and design new PSSs in a complex environment by utilizing the built framework. Throughout the innovation process, Design Thinking tools are employed, and assumptions are validated with the client.

Referring to the second research question, the "current status" online survey results indicated that external forces to the case company's business somewhat favourably support servitization. Internal capabilities in the case company's existing internal business were examined in greater detail in the study, with the following topics covered: KPIs and organizational alignment, value-based pricing strategy, product-service culture, customer-centric product-service co-creation, knowledge management, and efficient cost structure. The results indicate that the case company is committed to transforming itself into a more service-oriented organization. The data indicate that the case company is committed to organizational change in the direction of a service-oriented business, corroborating the indications of a new company strategy.

The results indicated that the strengths to leverage (Fig. 7) in the direction of servitization are the case company's professional and dedicated people, as well as the strong transformational forces that support strategic changes. The employees appear to be enthusiastic about driving a clear vision for cross-organizational development and PSS's. The case company's product portfolio is well-positioned due to its end-to-end capabilities, scientific innovation, and value-adding products with a tangible component of value. The value that the case company's hardware generates is an exceptional opportunity to capitalize on potential value-adding pricing and communication opportunities.

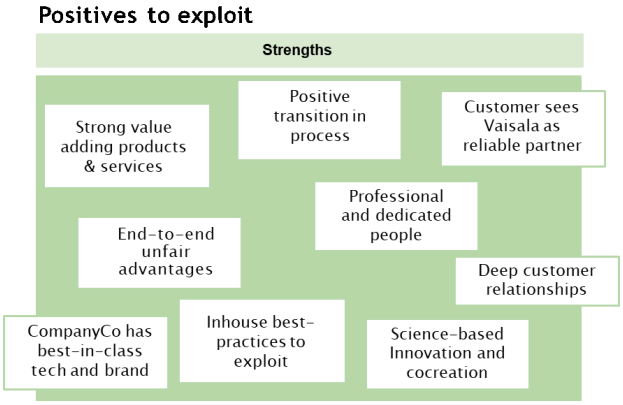

Fig. 7. Summary of internal positives to exploit towards servitization

According to the research, the pitfalls (Fig. 8) in servitization are the case company's unclear processes for customer information, which can be stored in multiple locations. Daily customer information flow is

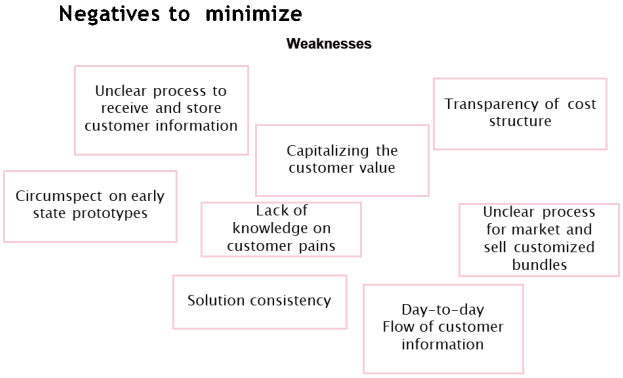

Fig. 8. Summary of internal negatives to overcome in moving towards servitization circumspection regarding early prototypes; capitalizing on customer value; selling customer bundles; lack of knowledge about ....

perceived to be on the shoulders of project managers, and the information process can be opaque. The transparency of cost structure in service offering is a work in process, but a possible pitfall in terms of servitization. Consistency in PSS solutions is a challenge, as is marketing, producing, and selling customized bundles. The findings indicate that hardware manufacturing traditions haunt the transition, manifesting themselves in the company's tooling and as a brake on early prototypes.

Contributions and Implications for Future Research

This work makes two practical contributions. First, it illustrates the approach practitioners may use to develop a PSS, or the elements they should consider in using Design Thinking methodologies. Second, it provides critical information about the types of challenges that other organizations may face during this process, allowing them to prepare accordingly.

In the future, it will be necessary to conduct comprehensive research on the PSS innovative process. Multiple previous studies have focused on either PSS innovative or Design Thinking, but none have examined the combination of PSS fundamentals and Design Thinking methodology. As a result, this study's objective was to develop a framework for PSS innovative that is iterative in nature and customer centered. This work is something that can be improved. It provides only a partial picture because the process was only partially tested; thus, it is necessary to obtain a broader view and determine the nature of the problems and challenges in the remainder of the process to facilitate further innovation and implementation of new PSSs.

Study Limitations

The current study sheds some light on potential future research directions on the current state of servitization and the PSS innovative framework, but it does have some limitations. First, the research was conducted in the Finnish measurement equipment industry, a highly specialized sector. Additionally, this is a qualitative study conducted by interviewing experts from a single organization's division. As a result, the results may be context-dependent. Therefore, caution should be exercised when extrapolating the findings to other industries (Yin, 2003).

Second, this is a case study. Thus, the theoretical framework's applicability is determined solely based on the research company. The result covers only a minority of the case company's employees, and only one framework is used. Multiple companies should have been studied to determine whether the theoretical framework (PSS innovative) is generally applicable. Moreover, to demonstrate the theoretical framework's applicability, the sample of cases should span the entire width of manufacturing industry.

Thirdly, the PSS innovative framework focuses on the Design Thinking innovation process, limiting PSS innovative frameworks to a minor role. The study approached the topic in a specific direction (iterative, customer-centric procedures), and other points of view could have been considered.

Case studies as a method can be highly subjective, increasing the possibility of researcher and interpreter errors. Additionally, semi-structured interviews with nine participants and an online survey with fourteen respondents were conducted. The number of interviews could have been higher to achieve a broader profile of answers. The number of interviews might have increased to obtain a more diverse profile of responses. Interviews and surveys are also prone to subjectivity on both the interviewer's and interviewee's sides. The interviewee could have misunderstood the question or the phenomena in their context, or the interviewer may have misunderstood something expressed by the interviewee, thus misinterpreting the results.

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