IET Collaborative Intelligent Manufacturing

Special Issue: 11th CIRP iPSS conference/Smart Product Service Systems

IET Journals
The Institution of Engineering and Technology

Strategic planning of continuous stakeholder involvement in the design of industrial product-service systems

eISSN 2516-8398
Received on 18th December 2019
Revised 29th February 2020
Accepted on 6th April 2020
E-First on 15th September 2020
doi: 10.1049/iet-cim.2019.0059
www.ietdl.org

Yvonne Haussmann[1,2] ✉, *Claas Christian Wuttke*[1]

[1]*Faculty of Management Science and Engineering, Karlsruhe University of Applied Sciences, Moltkestraße 30, 76133 Karlsruhe, Germany*
[2]*Project Management Agency Karlsruhe (PTKA), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany*
✉ *E-mail: yvonne.haussmann@kit.edu*

Abstract: Industrial product-service systems (IPS^2) are an increasingly important and profitable offering of manufacturing companies. Alongside specific design processes, the suitable integration of the customer and all other stakeholders is essential for the market success of IPS^2. In this context, a multitude of methods and processes have been published to date. The novel approach of this contribution consists in the consideration of the individuality of the design object and of the corresponding design process. Presented results are (i) a workshop-based procedure to analyse the design object including the goals and risks as well as the basic conditions of the stakeholder integration, (ii) a procedure to plan an individualised stakeholder integration process based on the analysis results and a collection and systematisation of 35 methods for customer integration, and finally, (iii) a condensed version of the approach which allows to apply the procedure on short notice. This work is based on a comprehensive literature research as well as on the results of three case studies.

1 Introduction

The relevance of industrial product-service systems (IPS^2) in practice keeps increasing [1, 2]. Some manufacturers of machine tools are already achieving a double-digit percentage of total turnover with services related to their physical goods. However, that requires clearly defined services as well as methods and processes for their design [3, 4, 5]. A multitude of design processes supported by methods has already been developed [1–7].

The design of IPS^2 constitutes specific challenges to companies, since tangible products, services, infrastructure and stakeholders must be integrated into a holistic system [1, 4]. One of those challenges is the detailed understanding of the stakeholders, their needs and constraints as well as their involvement in the IPS^2 design process [8, 9, 10].

Customer integration is the basis for the design of IPS^2: It is essential to consider customer requirements, ideas and feedback in order to be able to provide tailor-made IPS^2 and thereby attractive long-term benefits to clients. However, developing an offer from a single perspective poses the risk of a suboptimal solution. The integration of all stakeholders is essential to ensure the economic viability as well as the technical and legal feasibility of the requirements, as IPS^2 naturally have more points of contact with internal and external stakeholders during their lifetime than mere physical products [8]. In spite of growing attention on these issues in IPS^2 development, especially 'the insufficient use of methods' is still a problem [11].

There are approaches to be found in literature concerning methods for customer involvement in design projects [11–15], specific goals and risks [16–19] or aspects of stakeholder integration [10, 20–25]. What is missing is a holistic approach that merges the proposals to completely capture all relevant constitutive criteria.

This was approached by Wuttke *et al.* [26], where an individualised planning process for customer integration in the design of IPS^2 has been proposed – individualised meaning customisable to the respective company's situation.

The present work broadens this existing approach to give attention to all stakeholders. On this basis, stakeholders and their requirements can be identified and considered at an early stage to prevent omissions during the development process, and their different modes of involvement can be planned systematically to complete the IPS^2 design as effectively and efficiently as possible. The objective of this article is to present the complete procedure after the evaluation with three case studies, as well as a condensed version which allows to apply the approach on short notice.

2 Methodology

This work follows the action research approach. Firstly, the need for systematic stakeholder integration in the design process for product-service systems (PSS) is derived from literature, as well as an overview about selected methods available to fulfil this requirement.

The literature review is followed by a detailed presentation of the stakeholder integration process in Section 4, including the further developments that expand the first version of the approach introduced in [26]. These developments are based on insights from the literature research as well as practical specifications from three case studies. These use cases are described subsequently in Section 5. Table 1 presents the steps in more detail.

3 State of the art in stakeholder integration in IPS2 design

3.1 Procedure for searching and selecting relevant literature

Relevant papers were identified through a systematic literature review using the widely used Scopus database and a keyword scheme. The search query 'integrat* OR involv* AND custom* OR stakeholder* AND method* OR design* OR develop* OR prototyp* OR systematic*' AND 'product-service*' OR 'industrial service*' OR 'pss' had 889 results. An evaluation by title and abstract identified 87 of them as relevant. The articles that did not pass the evaluation either did not fit the topic (PSS is the acronym for a variety of terms such as passenger service system) or just touched on customer or stakeholder integration briefly with no further insights. Those that passed were reviewed thoroughly and incorporated in this paper if they provided a significant contribution to the subject matter. Fifteen articles passed this screening by offering practical approaches or covering important

Table 1 Research approach

Steps	Sections
scanning references for existing models, methods and processes supporting the integration of stakeholders into the design process of IPS^2	3.2, 3.3, 3.4
derivation of constitutive criteria for processes for stakeholder integration	4
development of a practicable proceeding for raising particular characteristics of constitutive criteria for specific design projects	4.1
composition of a portfolio of methods for customer integration – gathered from publications	4.2
development of a proceeding for selecting methods considering the aforementioned constitutive criteria	4.2
integration of the application of methods in the design process of IPS^2	4.3
development of a condensed proceeding for spontaneous use or lower sales volume IPS^2	4.4
presentation of the practical specifications utilised for the developments in Sections 4.1 and 4.4 – application of the previously introduced individualised customer integration process with IPS^2 providers	5

aspects such as goals, risks or methods of customer integration. During the thematic analysis, further 19 articles found by backward and forward reference searching were added to the final data set, resulting in a total of 34 articles.

The following summary of the literature review is divided into three sections: The basic conditions of customer integration in IPS^2 design and the methods for customer integration lay the foundation for the procedure's integral parts 'planning process' and 'selection of methods' that are covered in Sections 4.1 and 4.2, respectively. The review of stakeholder integration approaches in Section 3.4 is the basis for the enhancements to the first version presented in [26].

3.2 Review – customer integration in IPS2 design

To integrate customers in design processes of new products is a usual requirement of the marketing department – e.g. in the form of the voice of the customer [17]. However, this example shows the focus on analysing the needs of the customers. In addition, during the early phases of the design process, the customer integration is focused on the specification of the new IPS^2 [8]. Early customer feedback on first concepts – e.g. in the form of prototypes – can support the design process and avoid unsuccessful products [27].

The extension of the customer integration to the entire product design process allows to give more responsibility to the customer [16]. The concept of 'democratising innovation' consists of the insight that both enterprises and customers become more and more able to design products and services. Customers must be seen not only as informants but also as developers if they are integrated in later design process phases [18]. Doing so, it should be noted that '… the particular way in which customers are integrated has a major impact on the quality of use information gained, …' [9]. To successfully integrate customers in the entire design process it is necessary to use standardised routines and to provide sufficient resources for both – the customers as well as the developers [28].

The possibility of poor effectiveness or efficiency of the resources invested is one of the major risks of customer integration. To avoid or at least to be aware of potential risks of customer integration, it is necessary to analyse them before the implementation. This also applies to the goals of customer integration. Only if they are explicitly known, the customer integration can be focused [29]. Further goals and risks of customer integration can be taken from [10, 18, 19].

3.3 Review – methods for customer integration

Customer knowledge can be divided into explicit and implicit knowledge. While explicit knowledge can be communicated easily by using numbers and words, implicit knowledge can be called 'sticky' information and consists of emotions or subjective impressions that are context specific [30]. Many conventional methods like a simple questioning are useful to obtain explicit information, but not the implicit knowledge. Therefore, there is a need for a variety of methods that suit different settings and objectives of the customer integration.

For example, the evaluation of products and services can be supported by virtual user design, which enables customers to refine product solutions using a web-based tool. Applying emphatic design, the customer is observed using the product or service in their own environment [31]. To use the knowledge of extraordinarily experienced users, the methods lead user analysis [15] or customer advisory board [32] can be applied. Quality function deployment [12] is a sophisticated but broadly used method to transfer customers' needs into concrete specifications and to compare those with the competitors'.

Dahan and Hauser [30] focus on web-based methods. Six of those are evaluated concerning their ability to integrate customers without their physical presence, which is of high importance to this work. A procedure that starts to integrate the customer already in the phase of strategic planning is described in [19].

A collection of additional methods for customer integration can be found in [10]. Including the examples above, a total of 35 methods to support customer integration in the design process have been found so far.

Whilst these methods focus on the integration into design processes, customer integration is also used in other departments such as process optimisation, sales processes and so on. The methods used in these cases could also be adopted to be used for customer integration in IPS^2 design.

3.4 Review – stakeholder integration approaches

As IPS^2 providers assume operational responsibilities, they should analyse the dynamic environment of the IPS^2 throughout its lifecycle and consider it a key resource [33]. The cooperation of all stakeholders involved in the IPS^2 value chain and the shared value creation play a central role [10]. Crucial to stakeholder integration are the systematic identification of the stakeholder groups and the provision of IPS^2 designers with methodologies and tools to visualise the stakeholder network and its needs [21, 34].

There are three major aspects of stakeholder integration in design projects:

- *Identification*: To be able to take into account all groups that affect or could be affected by the IPS^2, a systematisation of these parties is essential. Stakeholders are grouped as three actors for knowledge transfer in [20] – information carriers, information collectors and information translators. Yip and Juhola [21] present four levels of stakeholder proximity: business environment, offering, product and service delivery. A visual summary of possible internal and external IPS^2 stakeholders and their connection to the value chain is presented in Fig. 1.
- *Prioritisation*: Once all relevant interest groups are known, their impact on the development project needs to be evaluated and their participation has to be prioritised. The Stakeholder Salience concept proposes a hierarchical classification of groups according to the variables power, urgency and legitimacy [22]. In [23], stakeholders are ranked according to their influence on and their interest in the IPS^2. A value mapping tool categorises stakeholders using different forms of value creation [24].
- *Continuous integration*: On the basis of the conducted stakeholder analysis, the role of the stakeholders and the degree of their integration in the design project is to be discussed. In [25], three degrees of stakeholder integration are explored: passive integration, reactive integration and mutual cocreation.

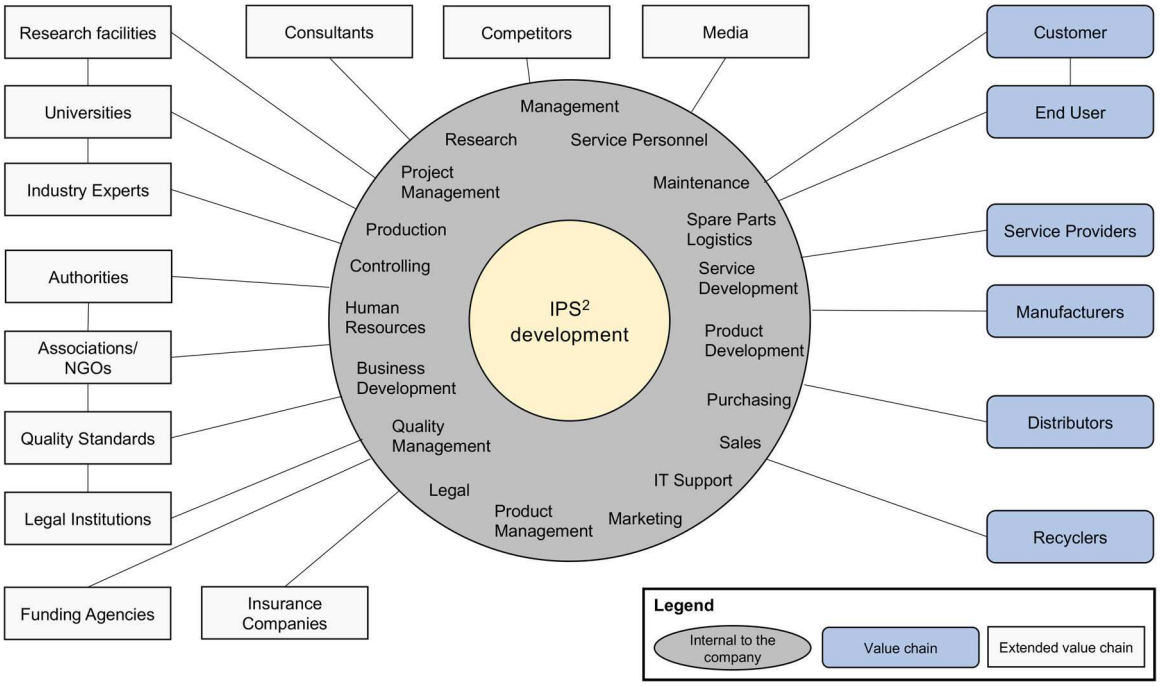

Fig. 1 *Possible stakeholders of an IPS² (adapted from [35], based on [21, 25])*

Pezzotta *et al.* [10] aim to extend the PSS lean design methodology from a customer-driven to a stakeholder-driven perspective. It focuses on providing a clear understanding of how stakeholder engagement can be handled alongside the four development phases without increasing the complexity of the development process.

Table 2 summarises the objects of investigation of the stakeholder integration approaches analysed in this study – showing that a holistic approach is still missing.

4 Planning of stakeholder integration

4.1 Specification and structure of the planning process

Based on the results from several research projects concerning stakeholder integration in IPS² design and completed by the authors' industrial experience, the specifications of a targeted and efficient stakeholder integration process are as follows.

The stakeholder integration needs to be planned so that: (i) its potential benefit is used in the whole design process, (ii) the modes and methods of the stakeholder integration are adapted to the concrete planning object and the individual design process and (iii) according to the particular goals and risks and with simultaneous consideration of the temporal and financial resources available.

To implement such an individualised stakeholder integration process, it must be planned before or at least at the beginning of the design process – allowing adaptions during its execution. This planning procedure of the stakeholder integration process is supported by a manual that contains guiding questions and possible answers to lead the procedure efficiently. Ideally, the procedure is performed in the form of an in-house workshop lead by a moderator who is familiar with the manual. A so-called stakeholder integration canvas allows to visualise the steps of the planning process (see Fig. 2).

The planning procedure is summed up in Table 3. In the first phase, the concrete design object and the basic conditions of the stakeholder integration are analysed as there are: level of maturity, innovation and individuality. A central issue that has to be clarified before planning are the goals on the one hand and the potential risks of the stakeholder integration on the other hand. Goals and risks referred to in literature are included in the manual and complemented from the practical results described in Section 5, e.g. unconvertible customer expectations, transparency about cost structure and pricing, distraction by less reflected customer contributions and so on.

Table 2 Objects of investigation of stakeholder integration approaches

Literature	Approach	Identification	Evaluation/ prioritisation	Role of the stakeholder
Gottfridsson 2012 [20]	knowledge conversion process	X	—	—
Yip and Juhola 2015 [21]	four-level model for stakeholder integration	X	—	—
Mitchell 1997 [22]	stakeholder salience	—	X	—
van Halen *et al.* 2005 [23]	influence-interest-matrix	—	X	—
Bocken *et al.* 2015 [24]	value mapping tool	X	X	—
Jonas *et al.* 2016 [25]	degree of stakeholder integration in three stages	—	—	X
Pezzotta *et al.* 2017 [10]	variation of PSS lean design methodology	—	—	X

On the basis of this analysis, the stakeholder integration is planned by performing the steps (iii)–(vii) as shown in Table 3. The steps (i)–(v) are supported by key questions and selective lists as shown in Fig. 2. Step (v) includes the systematic identification of all stakeholders – supported by a systematisation tool based on [21] – and the prioritisation of these stakeholders using the criteria *influence*, *legitimacy*, *urgency*, *value creation potential*, *business proximity*, *motivation* and *previous cooperation intensity*.

Especially the last two steps *Selection of methods* and *Integration of contact points into the design process* are challenging and therefore supported by tools and described in detail in the following sections.

Fig. 2 *Stakeholder integration canvas with key questions and selective lists to be used by the workshop moderator*

Table 3 Phases and steps to plan the individualised customer integration

Phases	Steps
(1) analysing the concrete design object and the basic conditions of the stakeholder integration	(i) documentation of project premises of the IPS^2 design project
	(ii) derivation and documentation of the goals and risks of the stakeholder integration
(2) planning the individualised stakeholder integration process	(iii) definition of the resources for the stakeholder integration
	(iv) determination of format and time of the stakeholder integration
	(v) specification of stakeholders to be integrated (identification and prioritisation of stakeholders, number of customers and intensity)
	(vi) definition of continuous stakeholder integration and selection of methods for the customer integration for each contact point individually
	(vii) integration of contact points into the product design process (PDP)

4.2 Selection of methods

In step (vi), a continuous communication strategy is defined for the relevant stakeholders. Depending on the preferred flow of information, role of the stakeholder, purpose of the involvement, environment and utilities, suitable instruments for the active or passive integration of the respective stakeholders are chosen. Part of the collection of instruments are e.g. newsletters, websites, social networks, workshops and focus groups.

Additionally, particular importance is attached to the integration of the customer. As described in Section 3.3, there are a number of references to various methods of customer integration. In this study, 35 methods that are useful for the design of IPS^2 – listed in Fig. 3 – are identified and structured according to their characteristics. Practical application has demonstrated that service managers tend to be unable to cope with the variety of methods. However, there is a significant relation between suitability of methods and quality of information gained by customer integration [9].

To give the planner additional support, there is a short description for each individual method that describes its course of action – thus only the selected method needs to be learned for its application, as the selection procedure itself does not require knowledge of the methods.

Six criteria for the selection of methods for customer integration have been determined (see Table 4). The six-dimensional selection is visualised by using a combination of two display forms presented in Figs. 3 and 4. Each individual method is represented by a special tag shown in Fig. 3. This tag displays the first four of the six selection criteria listed in Table 4 as well as an identification number for each method.

The procedure for the selection of the suitable method for a specific customer contact event is carried out as follows: after planning the customer integration in steps (iii)–(v) (see Table 3), the integration event is characterised concerning the suitable phase in the IPS^2 design process in which the customer is integrated (criterion 5) and the kind of input the customer is expected to provide (criterion 6). Applying this to the matrix, one of the 18 fields of the matrix is indicated. In the next step, the tags in the identified field are interpreted to find the method that fits best to the criteria 1–4.

Criterion 3 for example indicates the utilisation of IT. When possible, it can enable to integrate customers overseas, but if it is not necessary this can make the integration event more efficient and interactive.

4.3 Integration into the product design process

The definition of the phase of the IPS^2 design process in which the stakeholder should be integrated is not only required for the selection of methods but also to plan specific actions to implement stakeholder integration. This study builds on an appropriate prototyping process to support the design of IPS^2 ideas in a mixed team [7] as well as on the customisable design process for IPS^2 described in [6] (see Fig. 5), using the same phases to ease the allocation of the stakeholder integration points: (i) *idea generation*, (ii) *scoping of the design project*, (iii) *requirements analysis and business case*, (iv) *development of an IPS^2 concept* and finally (v)

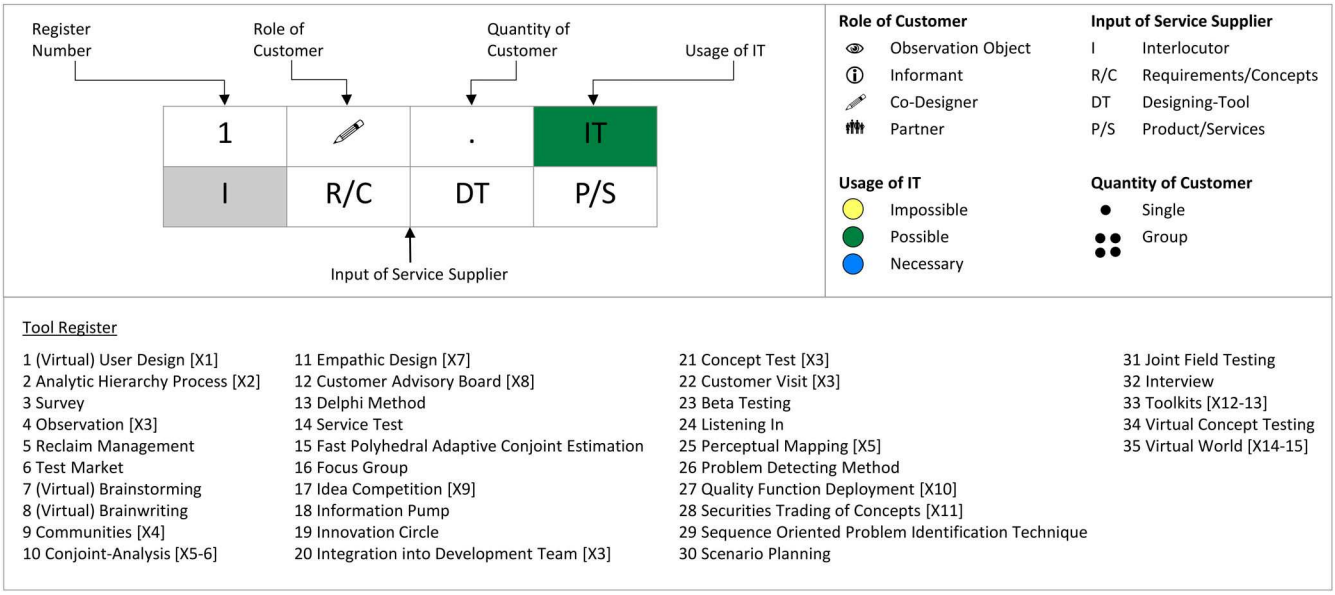

Fig. 3 *Coding of the methods for customer integration for their selection on the basis of multifarious criteria*

Table 4 Selection criteria for customer integration methods

Criteria	Instances
(1) role of the customer	observation object, informant, co-designer, partner
(2) quantity of customers to be integrated	single, group
(3) utilisation of IT	impossible, possible, necessary
(4) input of IPS^2 designer	interlocutor, requirements/concepts, design-tool, product/services
(5) IPS^2 design process phase in which customer is integrated	customer needs, evaluation of concepts of IPS^2, proposal of solutions
(6) input of customer	idea generation, potential analysis, requirement analysis, service conception, implementation and test, market launch

implementation and test. Each action with stakeholders is assigned to a phase and therein to a specific work package, described in detail in the respective articles.

4.4 Condensed version of the approach

The use cases described in Section 5 demonstrate that the handling of the workshop-based procedure requires experience and approximately half a day of group work. Not every development project has enough resources for this approach. Contacts to customers are often arranged on short notice – but still there is a need to prepare these meetings systematically. A condensed form of the methodology is required that allows for systematically integrating the customer with little preparation time.

In this context, a separate tool using a spreadsheet software is introduced. The questions and selective lists used in steps (i)–(v) are rearranged in a questionnaire that is completed by the person responsible for the customer contact. Step (vi) is redundant as the mode of customer integration is already set: The pending meeting itself represents the method of the customer integration. For each answer in the questionnaire, there are selectable options in the columns to the right:

- Preparatory tasks for the meeting such as the preparation of prototypes, documents or specific questions or arrangements that still need to be made.
- Stock phrases and questions to help address specific topics during the meeting.

After completing the questionnaire, a checklist is generated in a separate spreadsheet, containing all the relevant preparatory tasks and wording to comprehensively prepare and conduct the customer integration (see an example in Fig. 6).

This approach allows a time-efficient yet holistic consideration of all relevant aspects of customer integration for the short term. For example, goals and risks are examined in time for suitable measures to be taken to achieve or avoid them.

5 Case studies

The adaptability to the individual case is the central approach of the described stakeholder integration process. To demonstrate this aspect, the three use cases chosen to evaluate the approach introduced in [26] are different in many ways.

5.1 Digital production platform

The subsidiary of a leading machine tool manufacturer offers a digital platform for production to implement concepts of Industry 4.0. The platform supports the use of data from production machines as well as from partners in the eco-system to offer data-based ‘smart’ services. These services range from performance monitoring up to remote maintenance using augmented reality. The services provided by the platform may be used internally or offered externally on the market using the platform. The analysis of the basic condition of the customer integration showed the diversity of the eco-system as well as the customer topology as there are:

(i) operators of production sites that intend to gain transparency and agility by using production oriented smart services,
(ii) machine manufacturers that want to offer smart products and want to integrate their clients – operators of production sites – in their eco-system,
(iii) app-providers that want to offer their clients software-based services via the platform and finally
(iv) the parent company which is of such an importance that it is seen as an own category of customer.

The case study was performed in the form of a workshop with the heads of marketing, technology, software development and key accounting. The analysis of the design process showed that it is indeed very agile but nevertheless structured. Thereby, the premises for a systematic planning of the customer integration are given. Design projects are highly innovative as well as dynamic. They are carried out by a multidisciplinary and distributed team. Findings derived from the application of the customer integration process can be summarised as follows:

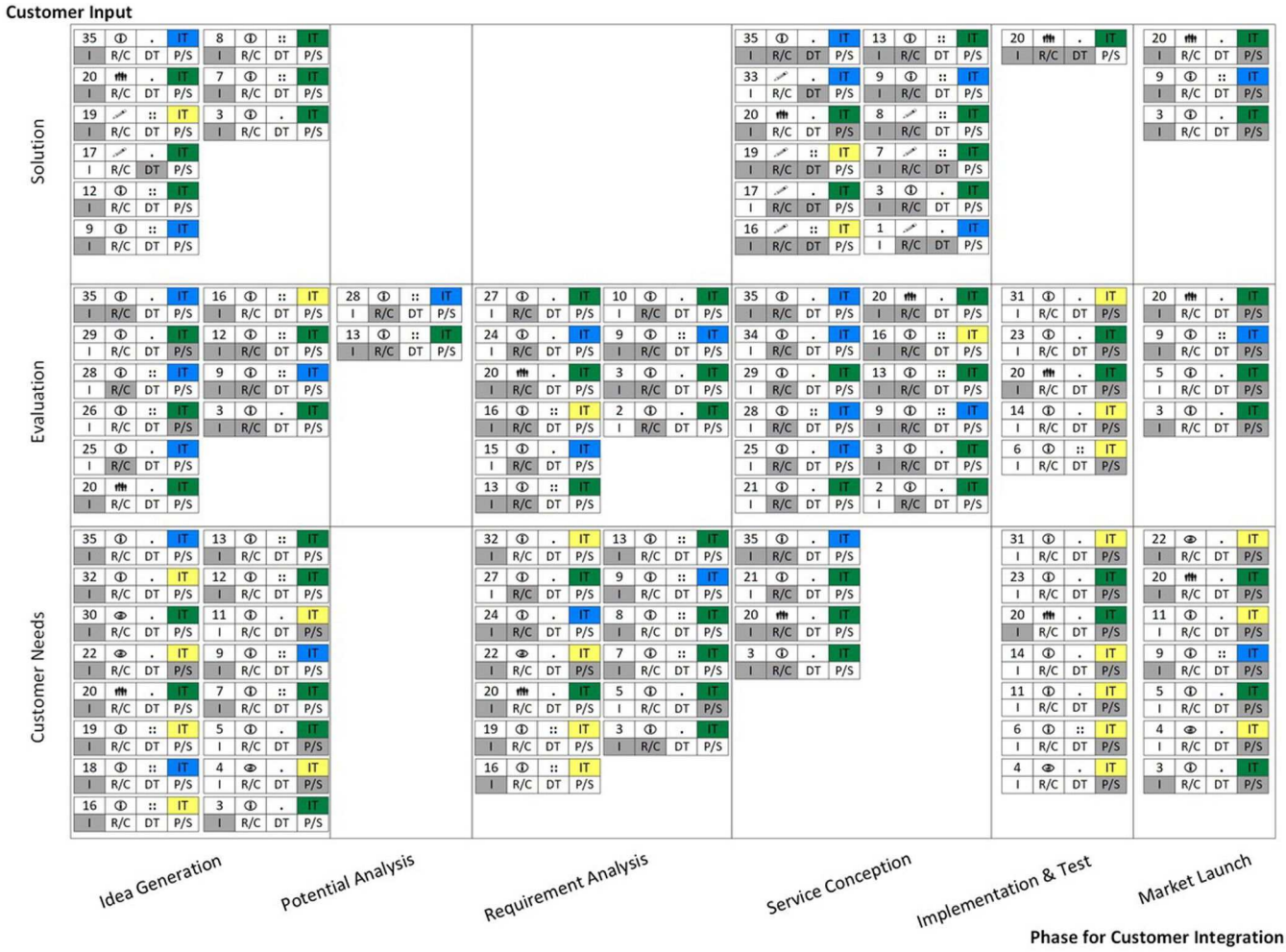

Fig. 4 *Matrix of methods for customer integration in IPS² design*

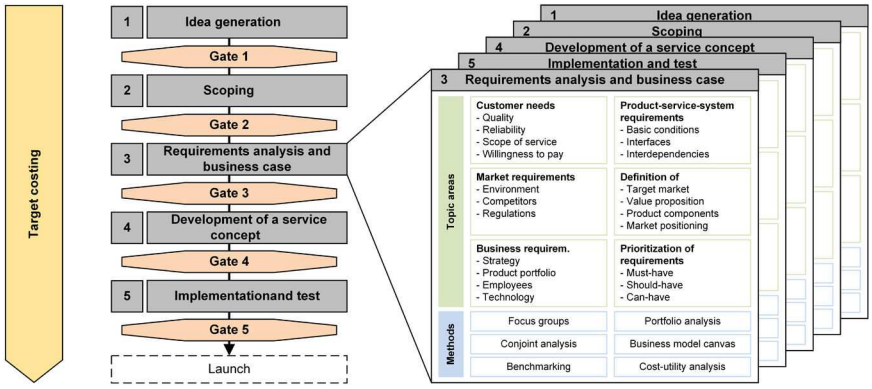

Fig. 5 *Adaptable and customisable design process for IPS²*

- The analysis phase was observed as very effective due to its detailed and clear structure. It also increased the transparency for the internal participants.
- The complexity of the examined case is – particularly but not only concerning the heterogenous structure of the customers – very high.
- A pre-analysis phase seems to be reasonable in such a complex case. Thus, especially the responsibility and resources for the customer integration process as well as the definition of the customer groups and the internal stakeholders can be clarified to avoid time consuming inquiries or obscurity.
- Given such a diverse customer structure, at least the analysis phase should be executed separately for each group of customers. An experienced moderator favours the flexibility with regard to individual requirements.
- The list of goals and risks is helpful but not complete. It should be replenished continuously. Newly identified goals of customer integration include the prioritisation of requirements, validation of own ideas, retaining rationality and customer focus. One significant risk is the generation of unconvertible customer expectations and the disappointment coming along with it. Therefore, expectation management is essential, and any confidentiality and language regimes must be clarified in advance. This consideration has been added to the planning of the form of integration (see Fig. 2). Other risks refer to the customer not being aware of what they really want, goal conflicts, distractions, as well as impatient, confused or upset customers as a result of unsuitable wording or timing for the engagement.
- When planning the form of integration and the selection of customers, it makes sense to include the current situation

separately and to highlight any target-performance deviations. This has also been added as a key question to Fig. 2.

- Customers show a high motivation to get involved in the design process because in this way they can influence and are a part of a highly innovative and prestigious process.
- The inclusion of all stakeholders into the approach is highly relevant to the platform business, even broken down to an employee level. At the moment, customers are prioritised according to their interest in and their influence on the IPS^2. Both positive and negative potential impacts on the project must be examined. For stakeholders other than customers, an extensive collection of methods is considered obsolete – instead a choice of communication tools could be useful to establish a stakeholder communication strategy. The implementation of this is described in Section 4.2 and reflects in the methods segment in Fig. 2.

5.2 Special purpose machine manufacturer

The second case study was performed in the form of an interview following the structure shown in Table 3. Participants were the vice president of Sales and Product Management Process Technology as well as the Service Process manager of the unit. The company develops, assembles and modifies machines for sophisticated manufacturing processes (e.g. assembly and testing, precision machining and wear protection coating). Customers of the machines and the related services are the plants of the parent company. They belong to different business units and therefore to different industrial sectors. The portfolio of services provided is highly multifaced which is a consequence of the technological demands of the offered production processes on the one hand and the individual specifications of the customers on the other hand. These are seeking for specific maintenance, process improvement concerning the quality and cost, optimisation of tool supply through to taking over manufacturing responsibility especially in the start-up of production systems. The services are highly individual and are arranged and specified on expert level.

Checklist for customer meeting — date: 31.12.19 — with: Karlsruhe University

Note: Consider a conversation time of less than one hour and prioritize topics as a precaution

Preparation tasks	Questions
General tasks	
Obtain participants' confirmations	
Clarify their preparatory tasks with the conversation partner	
Project frame	
Name, obtain and clear requirements or concepts for evaluation or extension by the customer	
Collect background information on competitors or market offer, as the service represents a novelty in the company	Are you also in contact with other companies offering this service?
	Have you already had experiences with this service with other providers and are there any suggestions for improvement?
Prepare unique features of the newly developed service	What features are important to you in this new service development?
Expectation management	
Select and prepare relevant prototypes for evaluation	
	How could the usability be improved?
Clarify language rules or guidelines	
Create and forward an agenda with topics for discussion	
Goals and risks	
	Can such a service help reduce your error rates?
Clarify on-site insight possibilities into product usage with the customer	
Prepare own ideas to validate	
Identify needs for clarification regarding a uniform understanding between provider and customer	
Consult with legal department on property rights	
Inform about the knowledge of the customer and if necessary prepare word choice and specific information to avoid confusion of the customer	
Resources	
	Do you have experience in the use of web-based services? This could facilitate our communication and coordination in the future.
Next steps	
Clarify resources and the right timing for a follow-up appointment with the customer and develop concrete suggestions	Do you generally have time resources in order to participate in the current or future design of services?

Fig. 6 *Example of a resulting individualised checklist for a customer meeting, including preparation tasks and questions*

- The high motivation of customers for their integration arises from the focus on customised services. Therefore, the goals of first customer contacts are primarily acquisition-based. Afterwards, effectiveness and efficiency of the design process become more and more important. A common understanding and terminology, combination of perspectives and idea generation for new services are seen as some of the main goals of customer integration. In this case, too, unconvertible customer expectations are identified as a significant risk. These results have been added to the list of goals and risks.
- To clarify strategic questions – e.g. the concept of a standardised platform for customisable smart services – the workshop-based approach is considered.
- As a consequence of the high individuality of the services, the respective potential sales volume is limited. Therefore, a separate planning of an individual customer integration process for each new service is not profitable.
- Contacts to customers are often arranged on short notice. The customer integration process – in a condensed form – is estimated as helpful to prepare these spontaneous meetings in a structured manner. The procedure should not take more than ∼30 min. Preparation tasks and a questionnaire adapted to the interview time are seen as useful outcomes of the process. These indications have resulted in the introduction of the condensed version of the approach in Section 4.4.
- The outcomes of the integration process are highly dependent on the conversation partners and their attitude towards the development project – see case 3.
- The integration of all stakeholders is given similar relevance as in the first case.

5.3 Provider of system solutions

The last use case was performed in the form of a technical discussion with a supplier of customised cutting-edge technologies in forming processes. Participants were the Service and Aftersales Logistics managers and the Service Product Development manager. In addition to forming machines, the product portfolio of the company also includes automation and software solutions, tools, process know-how and service for the metalworking industry as well as special purpose machinery. The intensive focus on digital business models promotes innovative system solutions. Customers are internal customers, automobile manufacturers and suppliers, companies from the forging, household appliances and electronics industries, as well as coin mills.

- Like in the first company, in this case the specification can be difficult as customers often do not know exactly what solution they really need, or which solution is possible. Particularly important is the choice of the contact person to minimise the risk of false impulses – see case 2. Functional challenges are encountered when choosing contact persons: different people in the company represent different interests. In this particular case, the customer's maintenance management team competes with the supplier – both offer a service. The outcome of a conversation may depend on whether the person is negative or positive about the IPS^2. This has resulted in the addition of a key question regarding the contact person to the stakeholder segment in Fig. 2.
- In this case too, the motivation of customers to be integrated is high. If a concrete benefit is seen by customers, they are willing to commit themselves without additional incentives of the supplier.
- A first draft of the condensed procedure in the form of a questionnaire was presented. It became clear that the customer

integration workshop and the questionnaire concept are to be seen as two separate aspects: the workshop is useful for planning a new development project, the questionnaire can be used spontaneously in all phases of the project.

- The greatest advantage of the questionnaire is seen in the comparability by standardisation and structure. Stock phrases are considered useful, as the experience of the participants shows that not every person can express themselves adequately in each environment.
- Extending the approach to other stakeholders is considered very important – in this case, up to 80 parties are involved in IPS^2 development. Differences between the organisational structures of the provider and the customer must be taken into account. In addition, there may be structural differences between individual departments of the same company.

6 Discussion and conclusion

It is becoming apparent that the development of IPS^2 and smart services will continue to change the industrial environment. It is therefore important to tackle these processes systematically and to use success factors such as the methodological integration of interest groups as an opportunity for profitable development projects.

In this study, the individualised customer integration process introduced in [26] is discussed with three different companies. These case studies differ greatly: a very complex eco-system on the one side, a fragmented and highly individualised service portfolio on the other and a very broad business model in the latter case. This allowed to examine the adaptability and limitations of the methodology as well as to derive ideas for further development. Although useful feedback has been gained and the specification with very different companies covers a range of perspectives, additional use cases are necessary for further evaluation.

The approach proposed in [26] is enhanced in three ways: using the results of a comprehensive literature search and practical specifications from three case studies, (i) the existing content of the methodology is complemented with up-to-date insights and (ii) amplified to suit the integration of all stakeholders – adding three specific questions concerning the systematic identification and discussion of stakeholders, supported by several tools. The presented workshop-based process is not suitable for IPS^2 with low sales volumes. Therefore, (iii) a condensed version of the approach is introduced in addition to serve the needs of development projects with fewer resources.

The results of this work can be applied directly in practice. Both the anticipatory holistic planning of stakeholder integration and the short-term preparation of a customer meeting are covered. The condensed version of the procedure still needs to be evaluated. Also, the collection of preparatory tasks and stock question cannot claim to be complete, which implies further research.

Its detailed structure makes the analysis part of the process very useful and also increases transparency for the internal participants. An optimised expectation management is essential to prevent the disappointment of customers demanding not deliverable results.

Despite the implemented enhancements, there is a need for future research. The procedure needs to be adapted continuously to ensure its practicality. Especially regarding the goals and risks of stakeholder integration, there are constantly new practical implications, as shown by this study's cases. The expansion of the collection of methods is not pursued in this work, thus its integrity is not ensured. The methods selection procedure could not be evaluated so far, which could be another focus of further work.

The greatest potential for optimisation lies in the tools for stakeholder integration: a big effort is involved in evaluating all identified stakeholders using the prioritisation criteria mentioned. Main stakeholders could be preselected to be discussed in depth, while using a shortened version of the prioritisation for the remaining groups to save resources.

7 References

[1] Meier, H., Roy, R., Seliger, G.: 'Industrial product-service systems – IPSS', *CIRP Annals – Manuf. Technol.*, 2010, **59**, (2), pp. 607–627

[2] Lindahl, M., Sundin, E., Sakao, T.: 'Environmental and economic benefits of integrated product service offerings quantified with real business cases', *J. Clean Prod.*, 2014, **64**, pp. 288–296

[3] Aurich, J.C., Mannweiler, C., Schweitzer, E.: 'How to design and offer services successfully', *CIRP J. Manuf. Sci. Technol.*, 2010, **2**, (3), pp. 136–143

[4] Cavalieri, S., Pezzotta, G.: 'Product-service systems engineering. State of the art and research challenges', *Comput. Ind.*, 2012, **63**, (4), pp. 278–288

[5] Kubota, Y., Murakami, F., Kimita, K.*, et al.*: 'The task to design highly service-oriented product-service system', *Proc. CIRP*, 2017, **60**, pp. 416–421

[6] Wuttke, C.C., Ludihuser, P., Bleiweis, S.: 'Adaptable and customizable development process for product-service systems', *Proc. CIRP*, 2016, **47**, pp. 317–322

[7] Ilg, J., Wuttke, C.C., Siefert, A.: 'Systematic prototyping of product-service systems', *Proc. CIRP*, 2018, **73**, pp. 50–55

[8] Nilsson, S., Lindahl, M.: 'A literature review to understand the requirements specifications' role when developing integrated product service offerings', *Proc. CIRP*, 2016, **46**, pp. 150–155

[9] Edvardsson, B., Kristensson, P., Magnusson, P.*, et al.*: 'Customer integration within service development – A review of methods and an analysis of insitu and exsitu contributions', *Technovation*, 2012, **32**, (7), pp. 419–429

[10] Pezzotta, G., Cavalieri, S., Romero, D.: 'Collaborative product-service systems engineering: towards an active role of customers and stakeholders in value co-creation'. Int. Conf. on Engineering, Technology and Innovation (ICE/ITMC), Funchal, Portugal, 2017, pp. 1247–1254

[11] Wilberg, J., Heitzer, F., Hollauer, C.*, et al.*: 'Goal system management for use-oriented product-service systems'. Portland Int. Conf. on Management of Engineering and Technology, OR, USA, 2017, pp. 1–7

[12] Lockamy, A., Khurana, A.: 'Quality function deployment: total quality management for new product design', *Int. J. Qual. Reliab. Manage.*, 1995, **12**, (6), pp. 73–84

[13] Leonard, D., Rayport, J.F.: 'Spark innovation through empathic design', *Harv. Bus. Rev.*, 1997, **75**, pp. 102–115

[14] Osterwalder, A., Pigneur, Y.: '*Business model generation*' (John Wiley and Sons, Hoboken, 2010)

[15] Urban, G.I., von Hippel, E.: 'Lead user analyses for the development of new industrial products', *Manage. Sci.*, 1988, **34**, (5), pp. 569–582

[16] Kaulio, M.A.: 'Customer, consumer and user involvement in product development: A framework and a review of selected methods', *Total Qual. Manage.*, 1998, **9**, (1), pp. 141–149

[17] Griffin, A., Hauser, J.R.: 'The voice of the customer', *Mark. Sci.*, 1993, **12**, (1), pp. 1–6

[18] von Hippel, E.: 'Democratizing innovation: the evolving phenomenon of user innovation', *J. für Betriebswirtschaft*, 2005, **55**, pp. 63–78

[19] Alam, I.: 'Process of customer interaction in new service development', in Edvardsson, B. (Ed.): '*Involving customers in new service development*' (Imperial College Press, London, 2006), pp. 15–31

[20] Gottfridsson, P.: 'Joint service development – the creations of the prerequisite for the service development', *Managing Service Qual.*, 2012, **22**, (1), pp. 21–37

[21] Yip, M.H., Juhola, T.: 'Stakeholder involvement in software system development – insights into the influence of product-service ratio', *Technol. Soc.*, 2015, **43**, pp. 105–114

[22] Mitchell, R.K., Agle, B.R., Wood, D.J.: 'Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts', *Acad. Manage. Rev.*, 1997, **22**, (4), pp. 853–886

[23] van Halen, C., Vezzoli, C., Wimmer, R.: '*Methodology for product service system innovation: how to develop clean, clever and competitive strategies in companies*' (Koninklijde Van Gorcum, Assen, 2005)

[24] Bocken, N.M., Rana, P., Short, S.W.: 'Value mapping for sustainable business thinking', *J. Ind. Prod. Eng.*, 2015, **32**, (1), pp. 67–81

[25] Jonas, J.M., Roth, A., Moslein, K.M.: 'Stakeholder integration for service innovation in German Medium-sized enterprises', *Serv. Sci.*, 2016, **8**, (3), pp. 320–332

[26] Wuttke, C.C., Deck, B., Haussmann, Y.*, et al.*: 'Individualized customer integration process for the design of IPSS', *Proc. CIRP*, 2019, **83**, pp. 83–88

[27] Exner, K., Damerau, T., Stark, R.: 'Innovation in product-service system engineering based on early customer integration and prototyping', *Proc. CIRP*, 2016, **47**, pp. 30–35

[28] Wallin, J., Parida, V., Isaksson, O.: 'Understanding product-service system innovation capabilities development for manufacturing companies', *J. Manuf. Technol. Manag.*, 2015, **26**, (5), pp. 763–787

[29] Kimita, K., Sugino, R., Rossi, M.*, et al.*: 'Framework for analyzing customer involvement in product-service systems', *Proc. CIRP*, 2016, **47**, pp. 54–59

[30] Dahan, E., Hauser, J.R.: 'The virtual customer', *J. Prod. Innov. Manage.*, 2002, **19**, (5), pp. 332–353

[31] Hemetsberger, A., Godula, G.: 'Integrating expert customers in new product development in industrial business – virtual routes to success', *Innov. Mark.*, 2007, **3**, (3), pp. 28–39

[32] Cooper, R.G.: '*Winning at new products: creating value through innovation*' (Basic Books, New York, 1988, 5th edn, 2017)

[33] Wiesner, S., Seregni, M., Freitag, M.*, et al.*: 'Effects of environmental dynamicity on requirements engineering for Complex systems', in Lödding, H., Riedel, R., Thoben, K.D. (Eds.): '*Advances in production management systems*' (Springer, Cham, 2017), pp. 255–262

[34] Beuren, F.H., Gomes Ferreira, M.G., Cauchick Miguel, P.A.: 'Product-service systems: a literature review on integrated products and services', *J. Clean Prod.*, 2013, **47**, pp. 222–231

[35] Tyl, B., Vallet, F., Bocken, N. M., *et al.*: 'The integration of a stakeholder perspective into the frontend of eco-innovation: a practical approach', *J. Clean Prod.*, 2015, **108**, pp. 543–557