Design Options for the Integration of Suppliers in Agile Development Projects

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Abstract: The shift from a seller's to a buyer's market catalyzes the rising demand for customer-individual products and shortens product life- as well as innovation cycles. In consequence, many companies implement iterative and flexible agile development processes instead of the well-established plan-driven approaches to fasten their product development and to increase the fulfilled degree of customer requirements. At the same time, nowadays hardly any development project can be implemented by a single company independently. Both the increasing complexity of technical products and the paradigm shift from a high degree of value added inside a company to the concentration on core competencies have led to the fact that the involvement of suppliers and development partners in the development process is indispensable. Due to the implementation of agile development processes, which are fundamentally different to the plan-driven approaches, new requirements for the cooperation of companies and suppliers emerge. These requirements are hardly addressed in existing literature and practice. Therefore, this paper aims at filling the research gap by deriving a model to describe the design dimensions with their related design options for the integration of suppliers in agile development processes for physical products.

1 INTRODUCTION

The high volatility of the market environment and the ever-increasing demand for customer-specific product solutions present companies with new challenges (Cooper, 2017; Ehrlenspiel et al, 2014; Schmidt, 2016). This transformation and the demand for constant innovation results in shorter product life cycles as well as shorter innovation cycles. Consequently, a rapid market entry is becoming a decisive competitive factor for companies (Schmidt, 2016; Abele and Reinhart, 2011; Minderhoud and Fraser, 2005).

To meet these challenges, companies are increasingly relying on agile development models, since the today well-established plan-driven models are less and less able to meet these new requirements. In contrast to plan-driven approaches, which are defined by a phase-oriented and linear process, agile development models are characterized by an iterative approach and focus on adaptability instead of following a stringent schedule [6]. Hereby, agile development models aim for a fast, flexible and efficient execution of projects, (Schmidt and Paetzold, 2018; Schoeneberg, 2014) as well as for a higher degree of customer satisfaction. In order to achieve this, a rapid adaption to changes in requirements and boundary conditions of the volatile market is necessary (Herrmann et al, 2009; Nerur et al, 2003). The targeted adaptivity makes it possible to introduce and implement changes late in the development process when using agile models (Ahmed-Kristensen and Daalhuizen, 2015).

One major characteristic of agile development approaches is the continous validation of development hypotheses and results by the build-up and testing of physical prototypes, even in the very early project phases. This constant development of physical prototypes pose a challenge in the agile development of physical products, as the iteration cycles – so called sprints of two to four weeks – provide a tight timeframe for the completion of physical prototypes. This completion depends heavily on the availability and punctual development and delivery of components e.g. by suppliers. In addition to that manufacturing companies

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increasingly focus on their own compentencies and force a higher degree of outsourcing of development services to suppliers, which makes the integration of external partners a critical factor for success (Dombrowski et al, 2015; Groher, 2003; Schuh et al, 2008; Spath and Dangelmaier, 2016).

Hereby the adaptability and flexibility striven for by agile methods places new demands on the design of supplier integration (Schmidt and Paetzold, 2016; Gregory et al, 2016). In the plan-driven product development, a predetermined schedule is followed and all specifications are defined at the beginning of the development process in form of a specification sheet (Nerur et al, 2003; Nerur and Balijepally, 2007). Therefore, a supplier gets all the information about his specific development activities at the beginning of the development project. This nature facilitates the management of the suppliers, since precise framework conditions can be defined and fixed. With the use of agile models previous forms of supplier integration must be reconsidered, since they don't meet the requirements of an iterative approach. Agile methodologies deal with the internal organizational structure of development processes and teams, but usually do not take supplier integration into account (Becker, 2014; Dombrowski and Karl, 2016). Also strategies, methods and procedures available in literature for integrating suppliers into the development process are based on the application of plan-driven development processes and are therefore no longer fully applicable. Consequently, the introduction of agile development approaches makes it necessary to adapt the integration of suppliers according to the new framework conditions (Dombrowski et al, 2015).

Therefore, this paper presents a description model, which is part of an overall solution approach for the demand-oriented design of supplier integration in agile development projects. The presented model comprises different design dimensions with related design options for the integration of suppliers in agile development projects and represents one of five partial models of an overall solution hypothesis for the development of type-based supplier integration forms for agile development processes (Schuh and Schröder, 2019). The core of this work is therefore to identify essential design dimensions of supplier integration in agile development projects and to develop forms or design elements that meet the new challenges of agile development of physical products

2 LITERATURE REVIEW: EXISTING APROACHES FOR THE DESIGN OF SUPPLIER INTEGRATION

In this paper, supplier integration is considered in the context of product development and refers to the organisation or design of the cooperation between customer and supplier
(Becker,2014) In literature various approaches for the design of supplier integration exist. These approaches differ strongly in their concrete focus as the design of supplier integration forms depends on a number of different factors. In this section, the most relevant existing approaches within this research field will be introduced and evaluated in terms of their relevance for the developed model. Tab. I depicts the core statements and the relevance-evaluation of the analyzed approaches (visualized in a discrete scale using Harvey balls).

Table 1: Supplier integration models.

Author	Core Statement	Rel.
Grober (2003)	Grober derives six different procurement relationship types from defined influencing variables. Based on a developed generic design **space in form of a morphological box, he derives individual recommendations for the design of the** supplier integration for each of this six relationship types.	◕
Denzler (2007)	Denzler concentrates on the ramp-up phase in the development process with regard to the customer-supplier relationship. The focus is on coordination measures, not supplier integration. Denzler defines relevant types of relationships through the development of influencing factors and areas of supplier coordination, which are typologized by means of procurement induced and supplier induced supply risks.	◕
Becker (2014)	Becker focuses on the research field "controlling of supplier integration". The design of supplier integration is not considered, but design recommendations are **given for integrative development projects. The characterization of** three dimensions and three process types on the basis of which controlling instruments can be selected is fundamental.	◑
Eisele (2006)	Eisele deals with verticaldevelopment partnerships and develops design recommendations with regard to structural organization, contract design and controlling. This **is based on four previously identified types of** development partnerships. Particularly relevant for this paper is the discussion of design variables and their respective characteristics anchored in the model.	◕
Kirst (2008)	Kirst focuses on the systematization of different supplier types on the basis of integration intensities. With regard to intensity, the time in the	◑

Author	Core Statement	Rel.
	product development process is also taken into account. For the identified supplier types, final task areas and associated characteristics of these are derived.	
Heinecke (2018)	Heinecke identifies influencing factors and requirements of customer-supplier-relationships from both perspectives. He takes existing **influencing factors from the literature and supplements them with the results of an empirical study.** Essential for this paper are the dimensions of business relationships that Heinecke develops in his analysis.	◑
Winter (2014)	Winter deals with supplier innovations and the prerequisites for their introduction. He divides these prerequisites into categories and considers interactions between them before giving **recommendations for the introduction of supplier innovations. For the categories, he also considers** supplier integration. In doing so, he determines the appropriate point in time of integration and uses the phases of the product development process as a basis.	◔
Schmidt (2017)	Schmidt analyses the contractual form of distributed product development projects. She **develops a model to illustrate the need for coordination, on the basis of which two types of** contract are analyzed and recommendations for action for the contractual design are made.	◔
İncekara (2014)	İncekara formulates design recommendations for vertical cooperation. The focus here is on the **connection between supplier integration and the degree of innovation.** İncekara **conducts an** empirical study to analyze the mechanisms of this relationship.	◑

The investigation of the existing literature shows that there is already extensive research in the field of supplier integration in new product development, including very different perspectives and concrete research issues. Groher e.g. presents a very holistic model for the design of integration forms while İncekara only investigates the influence of the degree of innovation on the integration of suppliers. But with regard to the outlined problem two major deficiencies can be identified. First and major deficit is the missing consideration of the effects and new framework conditions of agile development processes. Existing approaches neither analyze those new requirements on the design of supplier integration forms nor do they present new design options of integration forms which are adapted to those special needs of agile development processes. In consequence, these approaches are not or not fully applicable to agile development projects. As agile development processes become more and more common in the development of physical products, an adaptation of the integration forms to these new requirements is urgently necessary. The second major deficit identified is the lacking consideration of situational requirements and influencing factors in the design of supplier integration. The description of existing approaches is mainly based on different characteristics of an influencing variable, which, however, does not do full justice to the individuality of customer-supplier relationships.

Thus the overall objective of the presented paper is to identify the relevant dimensions for the individual design of supplier integration forms, evaluate their suitability for the use in agile development processes and adapt them, if necessary to the new requirements of these agile processes.

3 RESULTS: DEVELOPMENT OF A DESCRIPTION MODEL

The central intention of this paper is to derive a description model that outlines the design dimensions including the design options for a needs-oriented integration of suppliers in agile developments projects. In this context, a situational approach is necessary due to the complex and individual requirements in customer-supplier-relations as well as the involvement of many stakeholders in the development process. To develop a suitable and comprehensive model, two consecutive steps will be conducted. First, existing approaches for the design of supplier integration forms have to be examined and the included design dimensions have to be evaluated in terms of their relevance for the scope of this paper. Subsequently, the identified research gap serves as a starting point for the development of the description model or, in other words, the derivation of relevant design dimensions and their related design options. To execute these two steps and provide a framework for the model development, a basis for evaluation is necessary. Thus, criteria for the evaluation of existing approaches in literature and the subsequent selection of relevant design dimensions are determined in a prefixed step. Agile approaches for the development of physical products are practice-driven, leading to a limited number of available academic literature (Cooper and Sommer, 2016). Consequently, existing approaches and possible design dimensions were mainly derived from literature about supplier management as well as literature concerning adjacent research fields, like sourcing strategies, communication and cooperation in supply chains and organizational forms of vertical relationships. In addition, the authors' own experience from coaching and conducting agile development projects were an important input for the model development.

3.1 Framework and Requirements of the Model

In order to systematically develop the model, four criteria for the selection of relevant design dimensions and the evaluation of existing approaches of supplier integration were initially determined. These criteria were derived from the overall objective of this paper to address new paradigms for the cooperation and communication between customers and suppliers in agile development projects of physical products. Furthermore, these selection criteria can be assigned to either the object area or the target area. The criteria belonging to the object area examine the content consistency between the overall scope of consideration of this paper and the regarded approach from literature. The object area comprises the following criteria.

- **Physical product development:** The model is limited to design dimensions referring to development projects with a focus on physical products.
- **Agile methodologies:** The model is limited to design dimensions that are applicable for the implementation of agile methodologies in development projects

On the other hand, the criteria belonging to the target area take into account, if the goals of the regarded approach from literature are congruent to those of this paper. The target area comprises the following criteria.

- **Design of supplier integration:** The selected dimensions have to contribute directly to the organizational or processual design of the supplier integration.
- **Customized design:** The model user has to be able to choose between the different design options within the identified design dimensions according to requirements and the prevailing development situation.

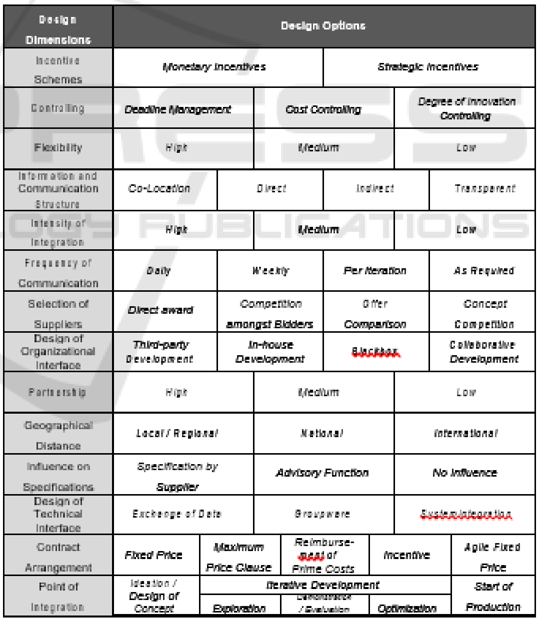
Based on these four criteria the total of 18 design features identified in the literature were evaluated and consecutively the relevant design dimensions and their belonging design options determined for the description model, developed in this paper. The description model and the selected design dimensions are explained in more detail in the following section

3.2 Design Dimensions and Options

This section depicts and explains the design dimensions and belonging design options of the description model for the needs-oriented integration of suppliers in agile development projects. The procedure described above for the evaluation of the identified design dimensions resulted in a selection of 14 essential characteristics for the design of supplier integration in agile development projects. These 14 dimensions and their belonging design options are depicted in Fig. 1. In the following a selection of these dimensions is described in details.

3.2.1 Information and Communication Structure

The integration of suppliers into the product development process requires an exchange of information and knowledge in order to put the ideas and contributions of suppliers in the right place and develop the product according to the customer's requirements (Jaspers and van den Ende, 2006). Not only the quality of the information exchange is relevant but also the efficiency, to minimize the costs of communication and reduce information asymmetries.



Design Dimensions	Design Options				
Incentive Schemes	Monetary Incentives	Strategic Incentives			
Controlling	Deadline Management	Cost Controlling	Degree of Innovation Controlling		
Flexibility	High	Medium	Low		
Information and Communication Structure	Co-Location	Direct	Indirect	Transparent	
Intensity of Integration	High	Medium	Low		
Frequency of Communication	Daily	Weekly	Per Iteration	As Required	
Selection of Suppliers	Direct award	Competition amongst Bidders	Offer Comparison	Concept Competition	
Design of Organizational Interface	Third-party Development	In-house Development	Blackbox	Collaborative Development	
Partnership	High	Medium	Low		
Geographical Distance	Local / Regional	National	International		
Influence on Specifications	Specification by Supplier	Advisory Function	No Influence		
Design of Technical Interface	Exchange of Data	Groupware	System Integration		
Contract Arrangement	Fixed Price	Maximum Price Clause	Reimburse-ment of Prime Costs	Incentive	Agile Fixed Price
Point of Integration	Ideation / Design of Concept	Iterative Development			Start of Production
		Exploration	Demonstration / Evaluation	Optimization	

Figure 1: Design dimensions and options for supplier integration

Regarding the differentiation of communication types as well as information channels, academic literature offers a variety of approaches. FREITAG e.g. differentiates types of communication, like *Direct (e.g. Face-to-Face)* and *Indirect (e.g. Telephone, e-mail)* (Freitag et al, 2011).

To minimize communication costs and ensure efficiency, an intensive and direct form of communication may not always be the best choice for all types of supplier integration. Rather, in many cases indirect forms of communication should also be taken into account. Due to the varying intensity of cooperation between suppliers and customers, both types of communication depict possible scenarios and were added as design options to the description model. Joint development projects with a high degree of supplier integration require a constant access to all relevant project information (Spath and Dangelmaier, 2016). To ensure a high accessibility to information for different users involved in agile development projects, in practice, so called social-business-platforms are used to ensure information transparency by creating an environment for wiki-systems consisting of project-related information that are collaboratively collected by project participants (Schröder, 2017 Flad, 2015). Hence, the design option *Transparent* was added to the description model, which implies the exchange of information in agile development projects with a variety of participants and a dynamic information stand, e.g. through the utilization of social-business-platforms. Last but not least, the establishment of a *Co-location* poses a further intensification of the direct communication form. This concept comprises the spatial integration of cross-company teams, which creates the continuous opportunity for face-to-face communication and exchange and reduces the likelihood for the not value-adding duplication of efforts (Groher, 2003).

3.2.2 Intensity of Integration

In the context of this paper, the intensity of integration refers to the point within the value chain where the supplier's services begin. In other words, it is considered how deeply suppliers' services intervene in the internal processes of customers (Engelhardt et al, 1993). Against the background of shorter product life cycles and the associated shortened development times, the intensive integration of suppliers has gained importance in recent years (Gassmann, 2006). Literature often points out correlations between the competences of suppliers, the time of integration and the intensity of integration. In this context, high competencies have a positive effect on the intensity of integration into development projects (Schuh et al, 2008). The evaluation of suppliers' competencies is carried out by means of the specific development task to be fulfilled or the characteristics of the object to be procured. To describe the intensity of supplier integration, the three qualitative design options High, Medium and Low were determined. When choosing an adequate intensity of supplier integration, companies have to consider the rising number of communication interfaces and growing coordination efforts which result from a higher degree of integration (Groher,2003).

3.2.3 Frequency of Communication

This dimension specifies how often or at what frequency the communication between customer and supplier should ideally take place. A high communication frequency is advisable for development projects with a strong involvement of suppliers, since the regular and quick exchange of information is of great importance for this form of cooperation. Agile procedures generally require a fast and highly frequented communication (Schröder, 2017). However, this general statement only applies to internal projects and must be considered separately with regard to external project communication and different possible scenarios. If the procurement object is precisely specified and its development can be conducted by the supplier without considerable influence of the customer, the frequency of the customer-internal project communication may be high, while the interface for external communication is rather low frequented. Another possible scenario is the close collaboration and mutual influence during development projects. In this case, the external communication pattern is dictated by the internal communication frequency of the project, which is primarily determined by the obligatory meetings within iteration cycles of agile development. The spectrum of the required communication frequency can therefore range from irregular, demand-oriented to high-frequency communication. Following this argumentation, the four possible design options As Required (communication only on demand), Per Iteration (periodic communication at the beginning / end of an iteration cycle), Weekly and Daily (participation at daily Scrum) were derived for the design dimension frequency of communication.

3.2.4 Contract Arrangement

Contracts provide the legal basis for cooperation between customer and supplier. Despite supplier relationships based on trust, the formulation of contracts should not be waived in order to avoid discrepancies and conflict situations (Groher,2003).. Within the framework of supplier integration, the drafting of contracts is of great importance, since the selection of the right type of contract influences the development efficiency of the product covered by the contract (Schmidt, 2016). The thematic focus of the design dimension contract agreement is on price conditions, as these constitute a key factor in the contractual design of supplier integration (Schmidt, 2016). Against the background of volatile product requirements and imprecise specifications that may even be modified over the course of a project, contractual regulations on price conditions are particularly relevant for agile product development (Opelt et al, 2012; Peterhoff, 2016). SCHMIDT distinguishes between different contract types in supplier-customer relationships based on the price-fixing mechanism. In the case of so-called Fixed Price contracts, the price and scope of services are precisely defined. This type of contract is therefore only suitable for procurement objects with known product specifications and a low degree of technological uncertainty (Schmidt, 2016). Contracts with a Maximum Price Clause are suitable for the conclusion of contracts characterized by higher uncertainties and offer greater flexibility compared to fixed price contracts in terms of price conditions (Schmidt, 2016). A guaranteed maximum price is a limit on the amount that the customer has to pay to the supplier, regardless of the actual expenditure the supplier had to afford for the project. Moreover, Incentive contracts provide the opportunity to determine the procurement price depending on the supplier's performance. By paying bonuses or charging penalties for not meeting defined targets, development risks are more evenly split between customer and supplier. As the product specifications do not have to be defined precisely from the outset, incentive contracts are particularly suitable for agile development processes (Schmidt, 2016). For the formulation of product specifications, so called Cost Reimbursement contracts offer the highest flexibility. Here, the contractor is paid the prime cost for development and production plus an additional fee for overheads depending on the final project scope. This procedure requires the complete disclosure of all project related activities and costs through the supplier and shifts the cost risk towards the customer. Cost reimbursement contracts are frequently used where a prompt start of production or development is required even though the specification sheet is not completed yet and may alter during the process (Schmidt, 2016). Another promising design option are so called Agile Fixed Price contracts proposed by OPELT (Opelt et al, 2012). Here, a cooperation model between the contractors is stipulated beforehand, which does not insist on a strict binding of the contracting parties and regulates the scope of the project as well as the cost framework in order to facilitate an easier exit from the project if necessary. Furthermore, the subject matter of the contract is defined on the basis of an adequately detailed vision, which can be reviewed and adapted within intended checkpoint phases. All of the above described contract types are applied in the context of agile product development with a shift in significance towards the more flexible contract types and were thus included in the description model as design options for the contract arrangement.

3.2.5 Point of Integration

The choice of the necessary or most suitable time to integrate the supplier into the development process is a major concern and thus probably the most frequently discussed design dimension in literature (cf. e.g. (Groher,2003; Denzler, 2007; Kirst, 2008; Winter, 2014)). The optimal timing depends on influencing factors such as the complexity of the procurement object and the competencies of the suppliers. Existing approaches in literature determine the point of integration on the basis of the different stages of the product development process, such as ideation, phase of product definition, concept development, product development and production start (Groher, 2003). For this paper, the point of integration was also determined with the different stages of the product development project, in additional consideration of changes through agile approaches. In contrast to plan-driven approaches, a major part of the clarification of technical specifications no longer happens in the product conception phase, but rather empirically through hypothesis formulation and validation within the framework of the subsequent iterative development phase. Consequently, the time slice of the conception phase is significantly lower in agile development projects and is thus consolidated in the design option Ideation / Design of Concept. To distinguish between different design options for the point of supplier integration within the subsequent Iterative Development phase, a classification of the different iteration types according to KANTELBERG was used. Accordingly, the design options Exploration (pre-development iteration), Demonstration and Evaluation (design and development iteration) and Optimization (optimization iteration) result (Kantelberg, 2018). Finally, the startup phase of production after the product development also constitutes a possible point of supplier integration at a late stage in product development and is expressed through the design option Start of Production.

4 CONCLUSIONS

An increasing number of companies is implementing agile development processes to meet the challenges of increasing innovation pressure. But in the world of physical product development, with its significantly decreased depths of added value over the last decades, an implementation of agile approaches can only be beneficial if suppliers are successfully integrated into these new processes. As discussed in this paper, a needs oriented design of the customer-supplier-relationship and the integration form is mandatory for an effective and efficient supplier integration. The presented model in this paper therefore seeks to provide a first solution for the design space of the supplier integration into agile development processes. Based on an evaluation of existing approaches in literature and the authors' experience from own agile development projects the developed model summarizes the relevant design dimensions and their different design options, suitable for the use in agile development projects. The developed description model of the design space is thereby just a partial model of an overall method for the situational design of supplier integration forms. Dependent on the respective procurement object and the prevailing situation in the development project the most suitable design options have to be selected for an effective and efficient development project. Both the time and monetary expenditure for implementation and the associated added value or influence on the overall development project differ greatly between the various design options. Thus, to complete this method, especially a logic to select the most suitable design options according to the concrete situation has to be developed in future research. A useful application of the presented design options in operational practice is therefore only possible in combination with this logic.

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