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BPMN^{+I} to support decision making in innovation management for automated production systems including technological, multi team and organizational aspects

Birgit Vogel-Heuser*. Felix Brodbeck*. Katharina Kugler***. Jan Passoth**. Sabine Maasen**. Julia Reif*****

**Institute of Automation and Information Systems, **Munich Center for Technology in Society, Technical University of Munich, Munich, Germany (e-mail: {vogel-heuser; sabine.maasen; jan.passoth}@tum.de)*

****Institute of Economic and Organizational Psychology, Ludwig-Maximilians-Universität, Munich, Germany (e-mail: {brodbeck; kugler; julia.reif}@psy.lmu.de)*

Abstract: A joined interdisciplinary approach from systems engineering, organizational sociology and psychology is introduced using an enriched Business Process Model and Notation (BPMN^{+I}) based modeling approach to support decision making on a management level for both mid-term decisions such as in-/outsourcing and short-term decisions such as fixing a weakness on site during start-up of a plant abroad or involving the design offices. This approach focusses on the actual collaboration between interdisciplinary teams within an organizational context by enriching BPMN with checklists applicable to all interfaces along the projects' workflow. Our contribution aims at supporting innovation management for automated Production Systems which depends on successful interdisciplinary collaboration.

Keywords: Business Process Model and Notation, Automated Production Systems, Multi Team Systems, innovation management, organizations, Model Based Systems Engineering, inconsistency management

1. INTRODUCTION

Interdisciplinary engineering projects are often subject to delay, cost overrun and quality problems or may even fail because of the lack of efficient information exchange between multiple interdisciplinary teams working in complex networks within and across companies (Vogel-Heuser et al., 2020). Even though integrated collaborative approaches have been widely researched, they mostly fail to integrate aspects pertaining to the collaboration in networks of teams and organizational systems. In this paper, we argue that the interdisciplinary engineering workflow even using Model-Based Systems Engineering (MBSE) approaches and tool support needs to be enriched by collaboration aspects between teams within a broader organizational context to support decision making on a management level.

Therefore, we integrate the perspectives of systems engineering, organizational sociology and psychology. We introduce an enriched Business Process Model and Notation (BPMN^{+I}) as a modeling approach to support decision making on a management level leveraging measures from all three perspectives, i.e. organizational changes, team and training measures as well as technological measures like tool support (cp. Fig. 1). By "enriched" we refer to supplementary models focusing on the actual collaboration between interdisciplinary teams within a broader organizational context.

Various examples (Kohn, 2013) justified the necessity of MBSE enriched by psychological and organizational models in innovation management. In this paper we will introduce a

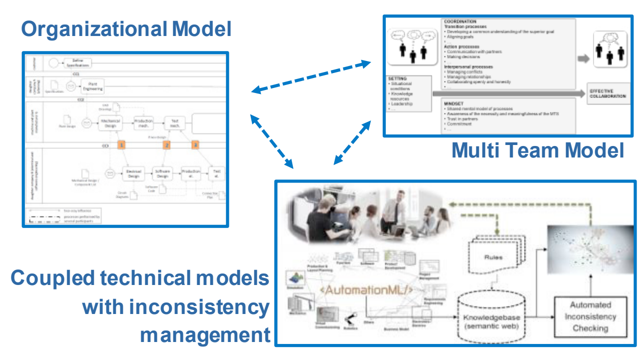

Fig. 1. Dimensions of potential means to improve cooperation: technical, organizational sociology and Multi Team models

method supporting a multi-dimensional decision in M&P by enriching BPMN with checklists evaluating the organizational and team aspects for all interfaces along the workflow in between companies and teams. For reason of clarity, we use the term workflow instead of process in the aPS domain to differentiate from processes like milling.

This paper is structured as follows. After introducing two industrial use cases (I and II) using BPMN^{+I} in Section 2, the state of the art in modeling of interdisciplinary innovation management is summarized in Section 3. Section 4 introduces for use case I - the long term in-/outsourcing decision - the proposed procedure as well as the assessment criteria for all cooperation interfaces. The approach is evaluated in Section 5 discussing the use case II - short term decision in start-up phase. A conclusion and outlook are provided in Section 6.

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2. INTRODUCTION OF THE TWO INDUSTRIAL USE CASES

The developed method will be explained by applying it to use case I (mid and long-term decision regarding in- or outsourcing of competencies like planning respective electrical and software engineering) and evaluated by application of use case II (short-term decision during start-up phase).

2.1 Use case I- in-/outsourcing of activities

Use case I is based on a much too late change of requirements by customer involving the workflow of a group of M&P companies (excerpt of this use case cp. Friedrich et al., 2002).

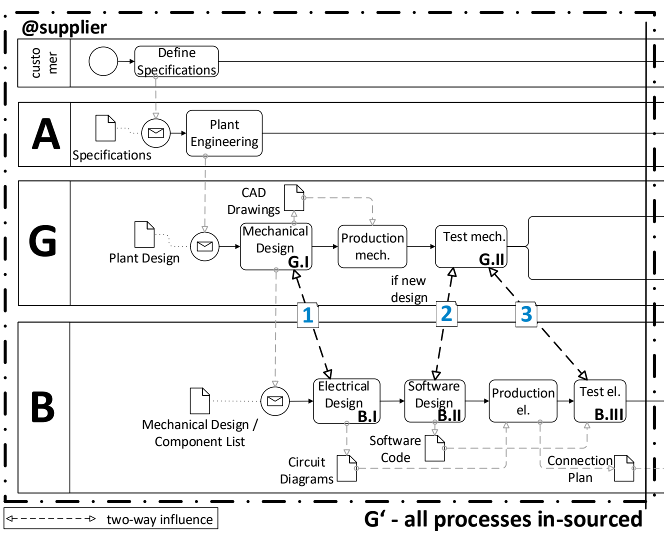

Fig. 2. Use case I - organization and team workflow with outsourced planning (plant engineering - A) and electrical/software engineering teams (B)

Use case I is derived from a real industrial company having undergone different reorganizations outsourcing both plant engineering (daughter company A) and electrical and software engineering (daughter company B) and insourcing both in another step more than five years later. We aim to objectify such decisions by expert ratings replacing pure gut feeling. Of course, most companies describe their existing business processes, i.e. workflows in at least flow charts as required by ISO 9001. During consideration of reorganization similar process charts of the potential new organization would be required to compare both. Collaborations (cp. Fig. 2) across teams (in company G, the general contractor) in between mechanical, production, testing and start-up are modelled in BPMN^{+I}. The inter-company collaboration (with G and B) are highlighted with interfaces 1-3 to show the close cooperation in between different disciplines instead of purely modeling the exchange of documents as usual in BPMN.

The test of the functionality of the mechanics is only feasible when parts of the software are already available (2). The acceptance test in house is only feasible with electrical control cabinets and software (3). Of course, this workflow is quite coarse grained, but already allows to discuss and evaluate criteria from interdisciplinary model transfers as well as team and organizational aspects. The evaluation is performed in comparison to the in-sourcing of companies A and B in the general contractor G (cp. Table 1, rows 1-3, numbering according to interface number). The next level of detail is introduced in use case II.

2.2 Use case II- short-term decisions support during start-up

During start-up phase, site manager of the general contractor G often need to make decisions without support of their office in case of urgency, lack in availability due to different time zones (Germany, New Zealand or west coast North America). We assume the same division of labor in between A, B and G as in use case I, but added other sub-suppliers like U1, who delivers only the mechanical and electrical part of a plant. The software needs to be delivered from B and U2, another sub-supplier, who delivers an entire component. Due to their size and necessity to be transported de-mounted, all components meet the first time on site during testing. In this case (orange highlighted in Fig. 5) all the different companies need to join forces and collaborate for integration test and optimization for different products. Additionally, we introduce more detailed units in mechanical engineering and different areas in electrical engineering (intentionally named differently due to potentially different layout).

We assume a necessary change in between the component of sub-supplier U2 and the general contractor G. The on-site personnel have to decide whether to change the software on site or describe the problem, report it to design offices of U2 and B and wait for negotiation in between both and the necessary software change to be provided. Often the change in software is necessary to cover mechanical weaknesses that are hard to fix on short notice. Therefore, the situation could be even worse: due to a weakness in mechanics of the unit 1 of G the software needs to be adapted by B and accordingly by U2. The comparison of both options (software change by design offices in comparison to on site) is shown in Table 1.

3. STATE OF THE ART IN MODELING OF INTERDISCIPLINARY INNOVATION MANAGEMENT

Innovations have been analyzed from the perspective of various scientific disciplines using different methodological approaches. For instance, psychological models analyze human experience and behavior (cf. Section 3.1), while sociological models highlight organizational processes (cf. Section 3.2). The interaction between social and technical aspects can be addressed by process and business models (cf. Section 3.3 and 3.4). Fleischmann et al. (2012) propose a subject-oriented Business Process Management which provides a framework for executing different behavior models without transforming them into a specific model language. They don't consider Model-Based Systems Engineering (MBSE) approaches and the required coupled tool support to ease cooperation. When it comes to aPS, a successful innovative design requires the collaboration of several disciplines. However, disciplines often do not understand each other's models, which hampers fruitful and beneficial collaboration processes. Kohn et al. (2013) introduce a framework to support common model understanding in a design research project. Kernschmidt et al. (2013) propose a joint modeling framework based on SysML neglecting the workflow, team and organizational aspects.

3.1 Model of effective collaboration in complex networks of teams

When individuals work on complex innovations of products like aPS, it is necessary to collaborate in complex networks often comprised of several work teams. Networks of teams that work towards a *common goal* are so-called Multi Team Systems (MTS) (Mathieu et al., 2001). They are defined as "two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals. MTS boundaries are defined by virtue of the fact that all teams within the system, while pursuing different proximal goals, share at least one common distal goal, and in doing so exhibit input, process and outcome interdependence with at least one other team in the system" (Mathieu et al., 2001).

MTS describe complex social systems that deviate from traditional, often hierarchically structured organizations (e.g. MTS may be heterarchically structured or span across multiple organizations; see DeChurch et. al. (2010); Mathieu et al. (2001)). Effective collaboration and collective synchronization of individual contributions are pivotal for accomplishing collective goals within MTS (Ancona et al., 1999; Marks et al., 2005).

3.2 Organizational and Interorganizational Aspects of Innovation Processes

Today, innovation processes require companies to integrate a multitude of dimensions - technical, financial, social, legal and organizational. Typically, this also happens under accelerated conditions of innovation (Rammert et al., 2017) as well as in a non-linear fashion (Argyris et al., 1978). This puts companies under increased pressure to orchestrate their innovation processes in a way that they constantly keep track of the multitude and possibly changing factors for an innovation process to be successful. When it comes to interorganizational relationships, challenges of coordination, control, legitimacy and problems of understanding (Vlaar al., 2006) among the involved organizations and units have been described. From an organizational perspective, first, the capacity of an organization to monitor the multitude of possibly changing factors and integrate the technical, financial, social, and organizational dimensions, second, the ability to reflect on the preconditions of its knowledge-basis and third, the lack of transparency regarding sequences of action (Moldaschl et al., 2007) have to be addressed. The chosen organizational perspective does not affect the other, technical models directly, but through constant or occasional reflection of the used tools and models with regard to the current conditions under which the very organization operates. Integrating such breakpoints for the reflection of organizational and interorganizational relations helps when evaluating the mid- and long-term consequences of rather technical decisions.

3.3 Data exchange in between partial models and proprietary tools in systems engineering of aPS

Data exchange is an important topic in the interdisciplinary development since various models and tools are used. AutomationML (AML), as an emerging standard in the engineering domain, can be adopted to represent and exchange artifacts between heterogeneous engineering tools used in mechanical, electrical, and software engineering domains (Lüder et al., 2017). Based on this standard, the different discipline-specific models can be linked into an AML repository (Biffl et al., 2017). Using queries, data in AML can be checked regarding their conformance with AML specifications (Wimmer et al., 2018). Moreover, a cloud-based integration and service platform to integrate different artifacts supports a distributed collaboration of multi-disciplinary engineers (Demuth et al., 2016). In the MBSE, model coupling and inconsistency management can help identifying bugs in between different models in the early phase (Li et al., 2019). We define inconsistency as the violation of discipline-specific design rules and interdisciplinary constraints. This definition excludes the high-level conflicts between goals and strategies of people. Instead, it focuses on the concrete information flow and artefacts in heterogeneous engineering models throughout the engineering workflow as shown in Figure 2 (interfaces 1, 2, 3), which reflect different engineering views on the same mechatronic system. Feldmann et al. (2019) propose a dedicated graphical modeling language to explicitly model the dependencies and consistency rules that must hold between the disparate engineering models. On this basis diagnosis and handling of selected structural inconsistencies are feasible. Such a data integration and inconsistency management support use case I from a technical point of view.

3.4 Business Process Model and Notation (BPMN) for interdisciplinary workflows

The BPMN, which is developed by the Object Management Group (OMG), aims to provide a standard notation for communication processes. Its main goal is to make those processes understandable through an interdisciplinary working environment and MTS. This work is based on the second version of the notation BPMN 2.0.

Hahn et al. (2010) introduced IT-enabled collaborative process modeling providing a set of guidelines and implications. Beerepoot et al. (2019) included differences in organizational size, culture and resources to improve business processes in the medical sector. They linked contextual factors to activities. Schmiedel et al. (2013) identified MTS aspects like teamwork, skill and collaboration etc. as culture supportive factors in academics and industry in different countries as a result of a Delphi study of achieving efficient and effective business processes: customer orientation, excellence, reliability, and teamwork. The same author team (2015) introduced a framework that explains the role of culture in BPMN. Decker et al. (2008) presented how BPMN and the Business Process Execution Language (BPEL) can be used to describe so-called Service Choreographies: interaction behavior in between different independent business partners. Our proposed notation includes interactions in iterative engineering.

4. PROPOSED ASSESSMENT PROCEDURE INCLUDING BPMN^{+I}

The proposed assessment procedure will be introduced first, including the notational changes for iterative interactions. Next the categories of these interactions and the respective assessment criteria are introduced.

4.1. Proposed procedure to evaluate different solutions

The proposed procedures (cp. Fig. 3) to evaluate different solutions for use case I and II are slightly different. The procedures have in common that they build on an existing BPMN model. Therefore, they can generally be used for projects whose goals are already clearly defined as decision support in the planning phase (cp. use case I) or for projects that are already ongoing in which an unexpected change (cp. use case II) requires a decision on short notice with complex constraints and interdependencies. The ability to compare different alternative process flows with our BPMN^{+I} approach makes it especially helpful for the responsible stakeholders who decide on the organization of the project (in use case I the general contractor G respectively the site manager in use case II). We assume that due to the ISO 9001 certificates at least a draft workflow model in a BPMN like notation will be available for all companies including interfaces to customers (use case I and G, as well as U1 in use case II). These models will need refinements to highlight the cooperation interactions. The optional organizational workflow (cp. Fig. 1, bold dashed line) would need to be modelled in the first step, step a)) of the procedure (cp. Fig. 3).

Consequently, also for use case II the BPMN^{+I} workflow model is assumed to be available and therefore step a) can be skipped in principle, but to evaluate the cooperation interfaces the workflow model needs to be analyzed to identify the relevant communication interfaces before entering step b).

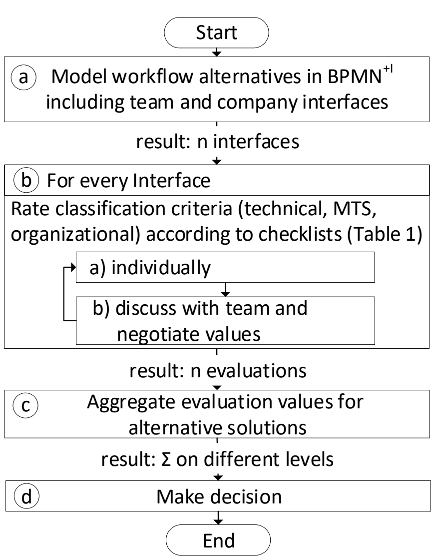

Fig. 3. Proposed procedure to support decisions on alternative solutions

In step b) for every communication interface a checklist including the three dimensions: coupled technical, organizational and Multi Team models are evaluated for the solutions to be compared to each other using the criteria introduced in Table 1. The evaluation can be first done by individual experts (like head of departments, specialists from organizational development departments or human resources), but the checklists can also be used in a second step for collaborative processes in the different teams to discuss arguments and to negotiate and leverage the values. Exemplarily for use case I this is given in Table 1 for all three interfaces and for both the in- and outsourcing alternatives in each cell. To allow comparison of different classification schemes like yes/partially true/no and (good/high)/ medium/(bad/low) as well as matching/partially matching/not matching always a three-level scale is used. To support the assignment of different weights in the sense of criticality, also a three-level weighing factor is introduced agreed by the expert teams that might be adjusted. As a result of step b) the leveraged ratings for both concepts for use case I are available. In step c) the values are aggregated, i.e. summed up for all criteria and every interface and finally for all interfaces, giving one value for both of the two solutions (row sum of points). It might be necessary to analyze communication interfaces on different levels of detail requiring the introduction of a second aggregation for the different details. Finally, in step d) the decision-making based on the criteria table should be taken.

Of course, the procedure relies on the competence of the experts and the team discussion process similar to well established procedures in systems engineering like cost tables and scoring models in value analysis (VDI 2800-8, 2010).

4.1.1. Proposed graphical symbols for BPMN^{+I}

Following the idea to model cooperation in Choreographies by Decker et al. (2008) we adapt the interaction between two teams from different companies to an iterative cooperative engineering process between for example the three different disciplines of a mechatronic product modelled as double arrow with a dashed line in BPMN^{+I} (+I for innovation). As we introduce checklists to evaluate different aspects of such cooperation and we assume that more than one cooperation may exist, numbers are added to the center of the dashed lines. These numbers refer to the column of the checklist table (cp. Table 1) in which the communication interface is evaluated with the criteria from team and organization aspects.

Additionally, we highlight cooperative activities performed by more than two companies using rectangles with chain lines (cp. Fig. 5 @customer site, right).

4.2 Categorization and introduction of assessment criteria

As aPS are complex multi-disciplinary systems about 47 different models (viewpoints) exist (Kohn et al., 2013). In the following, only three different dimensions (cp. Fig. 1) will be discussed because the different types of models (Reif et al., 2017) in between design, organization and psychology have not been invoked in one modeling approach, yet. To identify the advantages and disadvantages of the alternatives in both use cases several criteria need to be assessed (cp. Table 1).

For every interface five assessment criteria from psychology (12 sub-items) as well as organization (9 sub-items) are introduced. The available cross team and cross company engineering tool chain and data exchange is the fundament. It is included as separate criterion from a technical point of view.

4.2.1 Psychological aspects

To bring forth complex innovations, organizations need to rely on their employees. Complex innovations not only require creative individuals but also effective collaborations of individuals within teams, which again need to collaborate within complex networks of multiple teams (MTS) from diverse disciplines and backgrounds. Thus, managing complex innovations does not only require connecting technical models, it also requires supporting individuals and teams to successfully collaborate with each other in such complex networks. A psychological model of MTS collaboration (cp. Fig. 4) illustrates factors that support successful collaboration in complex networks of teams, which will be further explained in the following.

Effective collaboration within an MTS depends on factors associated with the **Multi Team Systems' (MTS) Setting**, for example, the level of **competence** and **reachability** of one's partners. While in-house partners may be more predictable and can be more easily evaluated, external partners may have more experience. Reachability can be increased by regional proximity, which may ease the accessibility, communication and coordination. Regarding MTS **transition processes** aligned goals between all partners facilitate high performance in quality and time. Goal alignment with external partners may be more difficult or at least needs to be established. The same applies to **action processes**. If work-related cycles are **entrained**, delays can be avoided. Entrainment with external partners may be more difficult or at least needs to be established. Furthermore, if existing communication channels can be used, delays and misunderstandings can be avoided. In-house action processes may profit from existing, also informal communication channels, which might be faster, whereas good communication with external partners has to be established. In addition, **interpersonal processes** also have to be considered. Relationship **conflicts** impair effective collaboration. Therefore, it is important that existing relationship conflicts are resolved constructively. Relationships between partners may fail, because they do not interact **openly and honestly** which is also crucial for an effective collaboration. If partners have a **MTS Mindset** (cp. Fig. 4 lower part), they have a **shared mental model** of processes and complexity in the MTS, **trust** each other and share a so-called MTS **spirit** between the teams. While trust in partners is the basis for effective collaboration, a shared understanding enhances collaboration and goal attainment. A MTS spirit may be existent in-house and may need to be established with external partners.

4.2.2 Organizational aspects

If the potential external partners are **members of interorganizational institutions** such as committees, industry organizations, standards bodies or networks, the probability that all partners subscribe to common standards increases. Such common standards can help to evaluate the likelihood of conflicts regarding quality and fulfillment procedures. Also, the degree of engagement can have an influence on the collaboration. If partners are **actively engaged in interorganizational institutions**, the frequency of their encounters increase and thus the ability to coordinate activities apart from project meetings and collaboration occasions.

Furthermore, the more similar internal company structures of external partners are, the better is the handling of contact points between them. **Similar degrees of formal organization** help managing contact points while mismatch, for example one partner with strict hierarchies cooperates with a partner with highly flexible teams, can decrease alignment of activities. The compatibility is not only depending on the similarity, so that more generally **compatible forms of formal organization** simplify the collaboration, while incompatible forms of formal organizations increase mismatches in terms of processes and responsibility and the need for extended coordination and support activities.

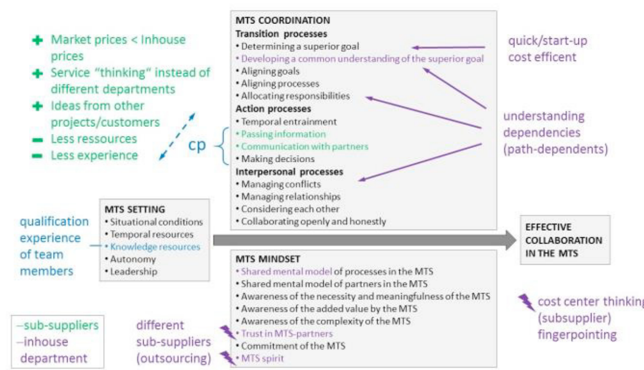

Fig. 4. Schema of effective collaboration in MTS for use case I comparing influences from organizational constraints (developed from Vogel-Heuser et al., 2020)

More informal arguments are the informal coordination and the organizational culture of the partners. Matching organizational cultures can increase convenience in terms of cross-organizational teamwork and knowledge sharing by grounding communication in a common set of shared understandings. Informal patterns of coordination such as common routines or shared experiences from previous collaborations, can decrease the need to formally regulate and structure teamwork, coordination and knowledge exchange. Also, personal relationships and networks between potential partners that are not project-related can help dealing with potential conflicts or accelerate the resolution. It helps to know who to call and when and personal relationships can help filling gaps in formal organization. However, personal relationships also bear the risk of creating new formal conflicts due to potentially unjustified high personal trust. Therefore, contracts and legal regulations are considered. Reliable regulation through contracts or law reduce the risk of collaborations with unknown and potentially untrustworthy partners in case regulations and contracts are enforceable. If enforcing the conditions of collaboration and dealing with liabilities require time and resources, delays are more probable when practical conflicts arise.

5. EVALUATION OF THE PROPOSED APPROACH

In the following the three different elements of the proposed approach were evaluated: First BPMN^{+I}, second the checklists to assess the cooperation interfaces and third the procedure combining both.

BPMN^{+I} could be successfully applied to use case II (cp. Fig. 5) as well but shows the limitations of visibility for larger decision dependencies without tool support. The scenario of use case II starts with the identification of a technical problem in mechanical unit 1 on-site (yellow block, green).

Table 1. Combined assessment criteria for cooperation applied to use case I and use case II (cp. Fig. 3 step b) and c))

Subject Area		Category	Classification	Weight-ing/ Prior-ity	Cooperation (Interface)					
					UseCase I Out/in (-sourced)			UseCase II On-site/design		
					1	2	3	1	2	3
Tools/Technological support		Engineering Tools and Interfaces	[g/m/b]	[1/5/9]	1/5	5/5	5/5	-/-	-/1	-/1
Psychological Aspects	**MTS Setting**	Competence	[y/p/n]	[1/5/9]	5/5	5/5	5/5	5/1	5/1	5/1
		Experience	[y/p/n]	[1/5/9]	1/5	5/1	5/1	1/5	5/1	5/1
		Reachability	[<1h/<1d/>1d]	[1/5/9]	5/1	5/1	5/1	1/5	1/1	1/5
	MTS Mindset	Shared Mental Model	[y/p/n]	[1/3/5]	3/1	1/1	1/1	1/1	1/1	1/1
		Trust	[y/p/n]	[1/4/7]	4/1	4/1	4/1	4/1	4/4	4/4
		MTS Spirit	[y/p/n]	[1/2/3]	1/2	2/2	2/1	1/2	2/2	2/1
	Interpersonal process	Conflicts	[y/p/n]	[1/4/7]	4/1	1/1	1/1	4/1	1/1	1/1
		Honesty & Openness	[y/p/n]	[1/4/7]	4/1	1/1	1/1	4/1	1/1	1/4
	Action process	Entrainment	[y/p/n]	[1/3/5]	3/1	3/1	3/3	3/1	3/1	3/3
		Communication	[g/m/b]	[1/5/9]	9/1	5/1	1/1	1/1	1/5	1/5
	Transition process	Goal Alignment	[y/p/n]	[1/4/7]	4/4	4/1	4/1	4/4	1/1	1/1
Organizational Aspects	**Interorgani-zational institutions (i.i.)**	Members of i.i.	[y/p/n]	[1/2/3]	2/1	2/1	2/1	2/2	2/2	2/2
		Engagement in i.i.	[g/m/b]	[1/2/3]	2/1	2/1	2/1	2/2	2/2	2/2
	Formal org. structure	Degree of form. Org.	[+/±/-]	[1/3/5]	1/1	1/1	1/1	2/2	2/1	2/1
		Form of form. Org.	[+/±/-]	[1/3/5]	1/1	1/1	1/1	2/2	2/1	2/1
	Informal coordination & org. culture	Org.Culture	[+/±/-]	[1/3/5]	1/1	1/1	1/1	2/2	2/1	2/1
		Informal patterns of coordination	[y/p/n]	[1/3/5]	1/1	1/1	1/1	2/2	2/2	2/2
	Contracts and legal regulations	Regulation of collab. conditions	[y/p/n]	[1/3/5]	3/1	3/1	3/1	2/2	2/2	2/2
		Enforceable regul.	[y/p/n]	[1/3/5]	3/1	3/1	3/1	2/2	2/2	2/2
	Pers. relationships and networks	Pers. relationships & networks	[y/p/n]	[1/4/7]	4/1	4/1	4/1	2/2	2/1	2/1
Sum of Points for each Cooperation Interface (lower values correlate with better criteria ratings)					**62/ 37**	**59/ 30**	**55/ 31**	**47/ 41**	**43/ 34**	**43/ 42**
Sum of Points for Project (step c))					**176 / 98**			**133 / 117**		

yes **n**o **p**artially **g**ood/high **m**edium **b**ad/low **+** matching **±** partially matching **-** not matching **h**our **d**ay

The site manager (company G) is addressed by the mechanical start-up staff (G, 1), who is not able to fix the problem mechanically and therefore proposes a software change to be conducted by the start-up electrician (company B, 2). Unfortunately, the start-up electrician B realized that due to his change consequently a software change of company U2 (3) is required (changed acceleration procedure). As U2 is only indirectly affected the start-up electrician should make changes that are not included in U2's scope of delivery and contract. Motivation for such an on-site bug-fix is high time pressure from customer side connected with a high penalty, but following the ISO 9000 procedure changes should be made by the design team (left hand side in orange) to assure an appropriate buck management. In this case (orange, dashed line) the start-up mechanic will contact his design office (1) and the design engineer (detailed mechanical design) will contact the software design (2) from company B and as a consequence software designer from U2 (3). The design departments will work on a solution and send it to the site. The start-up personnel will update the software on the affected controllers and test it.

The checklist delivered beneficial insights into the factors behind the cooperation interfaces for both scenarios, i.e. on-site change (green) or in design office (orange) for all three communication interfaces introduced (right part of the cooperation assessment cp. Table 1). The on-site change achieves higher meaning worse values (133) compared to the change in the design department (117). Nevertheless, on-site change might be the only option due to a weekend without 24/7 access to the design team or 12 hours' time difference in between site and design office. Especially for this use case additional factors are necessary to be included.

Finally, the procedure for the assessment using a checklist for the cooperation interfaces identified and numbered in BPMN^{+I} was rated beneficial as support for the interfaces to be dealt with comparing two alternatives by an interdisciplinary team from engineering, sociology and psychology. Using the checklists does of course not lead to definite guidelines for managerial decisions as each of the questions and assigned values is open to interpretation and judgement. However, the procedure helps individual managers and project planners to initially evaluate potentials and risks and serves as a collaborative tool for involved teams to come to common and therefore accepted and backed-up decisions.

6. CONCLUSION AND OUTLOOK

We introduced a joined interdisciplinary approach from systems engineering, organizational sociology and psychology including an assessment procedure based on an enriched BPMN combined with a checklist to support decision making on a management level. The procedure and notation was beneficially applied for two different use cases to increase transparency in decision making. Further evaluation is required. Future work will include the source of the rating for example, considerations based on historical and empirical data in order to obtain a more objective assessment. In addition, uniform guidelines for modeling should be established in order to ensure semantic precision and, thus, comparability of several alternatives. BPMN^{+I} is to the best of our knowledge the first combination of Multi Team, organizational and technological dimensions in one approach.

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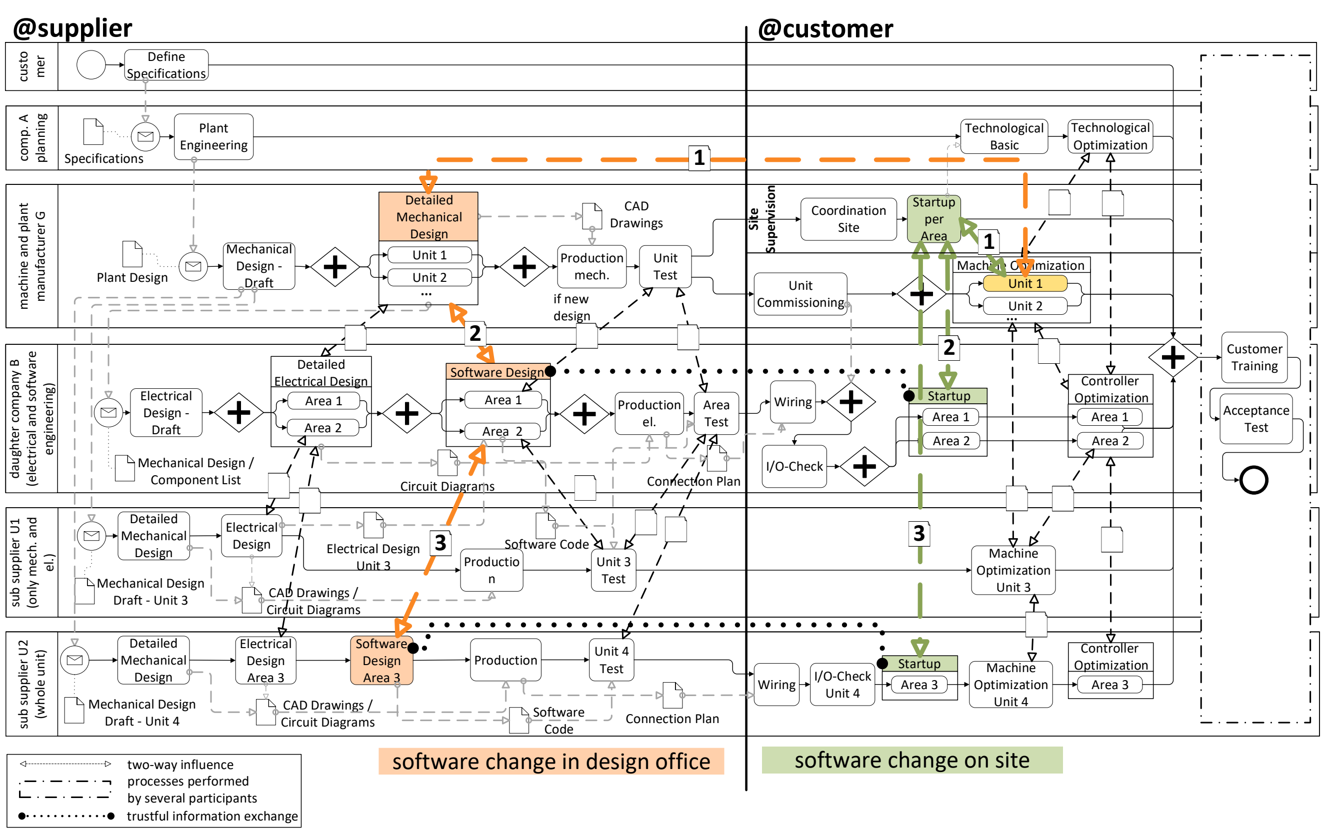

Fig. 5. Evaluation of proposed procedure and assessment criteria for short term decision for use case II in start-up phase

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