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STRUCTURAL MODELLING AND ANALYSIS OF ORGANIZATIONAL CHANGE DURING LEAN DEVELOPMENT IMPLEMENTATION

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Keywords: lean development, pilot projects, organizational change, structural modelling and analysis

1. Introduction

1.1 Motivation

Companies wishing to implement lean development (LD) must undergo a process of significant organizational change. Staff must first learn and understand the central idea and principles of lean. Once the need for process improvements becomes clear, methods to analyse the waste and develop actions to overcome shortcomings in the process can be employed. Even though literature about LD presents definitions and theoretic approaches, no holistic framework exists that indicates how to introduce LD for the first time. With the help of so called pilot projects, first steps can be taken and initial success accomplished. These projects make the philosophy better conceivable for the involved employees. They serve as flagship projects that allow for a small-scale testing before major changes are made [Fellbaum 1981/82]. If they are run by the company´s employees themselves, they support the self-help approach and therefore pave the way for a long-lasting implementation of LD [Helten et al. 2011].

1.2 Problem statement

Literature deals with LD and organizational change, but insufficiently examines the sub-processes and crucial situations during the change process in technical environments such as product development. As stated by several authors like Todnem By[Todnem By 2005], it is necessary to have a closer empirical look into real change processes to obtain evidence about important success factors for the management of change. In order to generate the mentioned pilot project schemes and to formulate instructions for the LD transformation, relevant change mechanisms during the implementation of LD need to be identified and understood. Thus, the structure of change processes must be modelled in detail to allow for an analysis. A meta-model and a modelling approach are generated to describe different change settings. Based on the analysis through structural criteria, main patterns are identified and different pilot project schemes are derived.

1.3 Research approach

In order to get evidence about important situations and mechanisms of the LD transformation, three current implementation projects in industry are observed and analysed. The authors have decided on a qualitative study to gain important insights into real change processes. This paper presents a research method that allows for a structural examination of organizational change processes with focus on LD. Based on literature about change management and LD as well as the authors´ experiences within the

project, a first set of domains and their dependencies is drafted to model the implementation process. The following analysis is conducted by means of structural analysis criteria, e.g. cluster, activity/passivity and number of nodes. Of further interest are structural changes over time, the quality of activities, and the complexity of actions. These aspects then need to be integrated into the concepts of pilot schemes. The current pilot scheme is presented in section 3.

1.4 Structure of paper

The paper first gives an overview of the central findings in literature regarding pilot projects and organisational change as well as structural modelling and analysis in section 2. The authors´ current pilot scheme as a basis of this research is explained in section 3. Section 4 shows the procedure of acquiring data that lead to the analysis of LD implementation and a new approach for modelling and analysing these qualitative data. Subsequently the proposed analysis steps are discussed (section 5), before the paper ends with a conclusion and an outlook.

2. State of the art

2.1 Pilot projects

According to Fellbaum [Fellbaum 1981/82] pilot projects serve as demonstration projects in the context of risky development projects. The risk can apply to societal, economic and technical aspects that are analysed under real conditions. Ehrlenspiel provides a model to implement the methodology of integrated product development that includes a pilot project. For the creation of a pilot project a company must assemble an interdisciplinary team, to identify the requirements of the pilot project, to consider the possibility of alternative projects, and to identify an appropriate project. Specifically, the process requires the analysis of the product development process (actual processes, documents, product portfolio, applied methods and tools, weaknesses), a structuring of order processing (relevant parameters, actual process, documents, methods and information), the generation and adaption of the methodology (standard processes, documents and results, sub methods), and a testing of the methodology [Ehrlenspiel 2007]. Helten et al. [Helten et al. 2011] emphasizes the need for pilot projects for the introduction of LD. For their design, the authors introduce nine categories and sub-categories (see Table 1). E.g. the category change management includes aspects such as the overall goal of the LD transformation, the initiator, the degree of urgency and the level of internal self-reflection. Furthermore, the sizes of the pilot project can be expressed through the duration itself, the relation to other projects, the number of involved employees as well as whether further employees are involved at any time during the project. Further categories are the stage of the project, the course of the project, the pilot responsibilities, the involved hierarchical levels, the experiences with process and product modelling, the transferability and the implementation.

Table 1. Main categories for the design of pilot projects, extract from [Helten et al. 2011]

Main Category	Sub-Category	Value/ Specification			
Change management	Goal of LD	Overall strategy	Process improvement	…	
	Initiation	Board of management	Project leader	…	Developer
	Degree of urgency	High	Medium	Low	
	Level of Self-Reflexion	High	Medium	Low	
Size of pilot project	Duration	3 months	6 months	…	5 years
	Relation pilot project/ major project	Fictive pilot project	Project as part of major project, common start	…	Project as part of major project, common end
	No. employees within pilot	5	10	…	> 50
	Involvement of further employees	Yes	No		

2.2 Change management

According to Moran and Brightman, “change management is the process of continually renewing an organization´s direction, structure, and capabilities to serve the ever-changing needs of external and internal customers” [Moran and Brightman 2001]. Todnem By reviewed main literature about organizational change management and adopts a categorization by Senior [Senior 2002] to differentiate three aspects of change. The main categories are the rate of occurrences (e.g. (dis)continuous or incremental), how it comes about (e.g. planned, emergent) and scale [Todnem By 2005]. Besides this general classification of change patterns, authors have developed several models that name important steps to manage a change process. Amongst the most famous is the model of Kotter [Kotter 1995] that includes eight main steps for a successful change project (1. Establishing a sense of urgency, 2. Forming a powerful guiding coalition, 3. Creating a vision, 4. Communicating the vision, 5. Empowering others to act on the vision, 6. Planning for and creating short-term wins, 7. Consolidating improvements and producing still more change, 8. Institutionalizing new approaches). Even if the approaches differ, they are based on the idea of clearly defined phases that are run through sequentially or iteratively.

As stated in the introduction, this research is embedded in a project about the implementation of LD. LD focuses on customer value and aims for the elimination of wasteful activities. Womack et al. state five principles for lean processes: value, value stream, flow, pull and perfection [Womack et al. 1990]. Given the classification chosen by Todnem By [Todnem By 2005] and mentioned pilot projects, a change based on LD can be seen as both incremental and continuous as well as an emergent process. Lean principles and methods can be of varying scale, but in any case a corporate transformation is necessary. Following the steps of Kotter [Kotter 1995], the implementation of LD will fail if the need to eliminate waste is not evident and the way to create more value is not clear. The chosen methods must guarantee short-term wins, but the long-term goals – such as a shorter Time-to-Market – must become tangible as well. The engineers and surrounding corporal functions need to be integrated into the change, e.g. core teams can be the “guiding coalition”. The product development process must be enhanced by LD elements to ensure a long-time implementation of the lean philosophy and the continuous search for improvement.

2.3 Models in product development

Through models people try to depict reality. According to Stachowiak models depict a natural or artificial original structure, and do not include all theoretically possible attributes. The creator of the model needs to decide on the extension and the expressiveness of the model. A model is never a comprehensive representation of one reality, but fulfils certain requirements such as the addressee´s requirements, the relevant time interval and the important operations to be considered for a further interpretation [Stachowiak 1973].

2.3.1 Modelling

According to [Lindemann et al. 2009] the management of structural complexity requires five steps. First the system under consideration needs to be defined. This leads to the formulation of a meta-model that includes important domains, elements and dependency types. The necessary data is then acquired by means of databases, modelling tools and interviews. This second step leads to the direct interdependencies of the system. After the deduction of indirect dependencies within the system, the structure is characterized by applying structural analysis criteria. Finally this analysis paves the way for an improved system management and design.

2.3.2 Analysis of models

Structural analysis criteria in engineering have been applied mostly on technical systems such as products and engineering processes. In general the structural analysis allows for the identification of main attributes. These attributes characterize a system in general – what are the most influential elements? How do they interact with the whole structure and the underlying system [Lindemann et al. 2009]? Lindemann et al. give an overview of basic criteria to characterize such structures. The active

and passive sum indicates whether an element is highly influential or is influenced by others. Bridge edges are the single connection between different subsets of elements. Their individual interruption or failure will cause changes in the entire following subsets. The closeness of an element (number of nodes reachable by a specific node) can be an indicator of the element´s relevance. In case of end or start nodes and leafs as well as isolated nodes a slight integration into the system can be detected.

3. Pilot scheme

According to the authors of this paper, an appropriate pilot scheme describes the first-time and holistic introduction of LD into a company. To serve a long-lasting implementation, the pilot scheme needs to guarantee consistency and an autonomous application by the company. Pilot schemes need to be adapted to a specific company context. Figure 1 shows the first draft of a pilot procedure. The aim is to derive different pilot schemes. As an example, a type 1 is shown. The appropriate pilot scheme is identified according to three main aspects that seem the most influential based on the project experiences. These aspects are the company characterization (e.g. company size, number of customers, type of good and composition of product development team), the lean background (e.g. experience with lean production) and the change capability (e.g. history of changes in general, communication tools for change). The scheme itself consists of four elements – analysis, synthesis, realization and implementation. The pilot scheme as depicted in figure 1 is a draft, but does not seem adequate to explain the complex processes in detail. The hatched areas between the elements as well as during the elements themselves indicate that the sequence is not easily and clearly definable. These hatched areas in particular are in the focus of the research. The structural approach is meant to make them understandable.

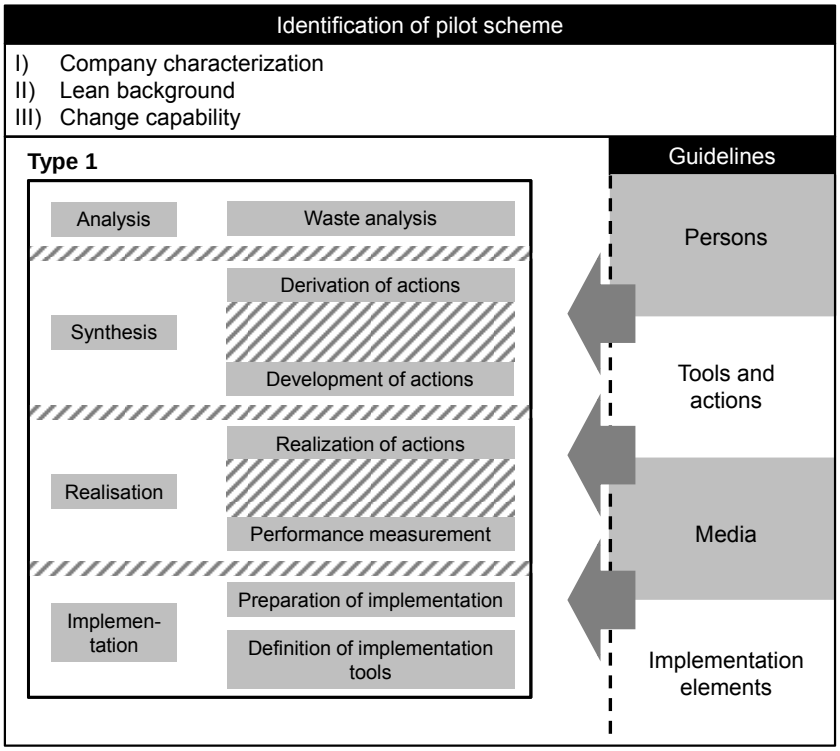

Figure 1. Pilot scheme concept

During the analysis the main waste and wasteful activities are identified. During the synthesis, actions are derived and further developed. Even though literature about LD mentions different actions such as set-based engineering or standardization, the companies need to undergo this phase on their own to follow the self-help approach. The realization ends with the performance measurement. The final implementation must include a preparation of the implementation and the definition of the appropriate implementation tools and actions. In addition, guidelines are formulated that indicate which persons,

tools and actions as well as media need to be integrated at what point and to what extent. Furthermore, the scheme proposes different implementation elements such as core teams.
It is conceivable that different pilot types require the same guideline elements, but in diverse constellations. Moreover, the project experience shows that the process cannot be described by the sequential model of different phases. The elements do overlap for example, because findings during the action definition could initiate another waste analysis. These shortcomings led to the idea to use a structural model to analyse the underlying change processes.

4. Approach for the structural analysis of organizational change

4.1 Data acquisition

The data acquisition is based on observations during three industrial LD implementation projects. In a single company the whole process is supported and investigated – from the initial waste analysis to the realization of actions and the implementation into the internal processes.
As described by Helten et al. [Helten et al. 2011] this form of observation is characterized by elements of action research. During the research the authors interact with the system, e.g. by moderating meetings and giving continuous academic input. Important lessons learned are directly integrated into the following research steps. Following this method of action research, researcher and research objects are equal, the topics and findings are of practical relevance, and the research process becomes a permanent learning and change process itself [Bortz and Döring 2006]. The authors assessed this approach as the most suitable, since the aim is to investigate possible ways to support a self-help approach in industry. By simply giving theoretical input, obstacles and scepticism could not be reduced. With regard to pilot projects, participants from industry need to learn to act as autonomously as possible. As stated by Ottosson it is essential for the researcher to be part of the process, because this allows for insights that could not be obtained in a different way. Less misunderstandings occur and situations do not need to be reconstructed afterwards [Ottosson 2003].
While the project is in progress, main activities and situations are monitored in detail. The observation sheet mentions the date and the involved persons. Furthermore, it differentiates between project logical and problem solving steps which are described by activities, the motivation behind and the output of the activity. Finally any feedback from industry is documented – what did happen about the precedent steps, is the procedure clear, which adaptations and changes to the procedure are necessary? A project logical step is a planned activity that is necessary for the implementation of LD such as a waste analysis. The unpredicted involvement of the top management to reactivate inactive activities is an example of a problem solving step.

4.2 Modelling organizational change during LD transformation

Based on a literature research, a first set of domains and dependencies is drafted, see figure 2. This set is used to model exemplary situations that could occur during the LD transformation. At the same time relevant analysis criteria are identified that fit with the analysis scope. In a next step, the most relevant situations from the observation sheet are extracted. Altogether, the sheet consists of about 100 records for one company. Before modelling these situations from real change processes during LD transformation, the situations are interpreted as a whole. Used as guides are recommendations from literature and, mostly, the experiences from the project and the final evaluation of the industrial partners. By the end of step 1 it is necessary to control whether the modelling approach meets important requirements. The approach needs to guarantee a certain degree of completeness – main aspects of the crucial situations must be integrated. The model elements need to be understood by unbiased persons. Then the model must show specific elements of the LD context such as principles and waste types. The comparison of the first draft and the interpretation will show whether the structural model represents the urgency and the challenges of change appropriately. The interpretation in combination with the continuous alignment between the model and the analysis leads to the decision whether certain patterns such as a cluster are to be interpreted in a positive or negative manner in a specific context.

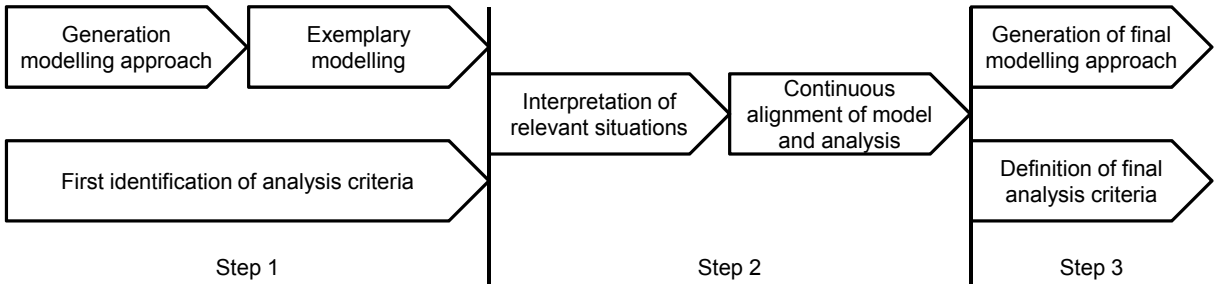

Figure 2. Procedure during modelling

4.3 Modelling approach for organizational change

Table 3 gives an overview of the most important domains and elements of the meta-model. So far the domains of the meta-model are people, waste type, action type, lean principle, analysis tool, execution of pilot LD project, implementation and lean phase. In some cases a domain consists of sub-domains. Furthermore, some domains contain elements of two different levels. The elements on the 1st level are more generic than the ones on the 2nd level. For example an engineer is first characterized according to the management level (top management, middle management, project engineer), and then mentioned as a special person A. In addition, he or she is member of a specific department. A specific form A could be necessary for a standardization action that again is located in the domain "Action type".
Main types of relations are shown in table 2. It is possible that

- a relation type is valid for the correlation between different domains: "Is needed for" relates "Analysis tool", "Action type" and "Implementation method and tool" with "Lean phase",
- two types of domains can correlate through different types of relations: "Person" can "be responsible for", "take part in" and "know about" an "Analysis tool" or an "Action type",
- elements of the same domain can interact with each other: a "Person " can "train" another person.

Figure 3 shows an exemplary model. Persons A and B both take part in a questionnaire that identifies waiting as a relevant waste type. A standardization approach by means of a specific form A is defined to eliminate the waste. Person A as a project engineer is responsible for this action type, Person A as top manager knows about it. Person A additionally works in sales, whereas Person B is assigned to product development. By involving these persons the LD idea is anchored by the implementation elements "support of top management", "building of a core team" as well as "naming of internal responsible person". Whereas the former implementation elements focus on the implementation "on the road", the implementation of the action type "standardization" is implemented through the method and tool "working instruction". The model shows in addition the related domains to the elements.

Table 2. Main types of relation for structural change modelling

Domain	Type of relation	Domain
Analysis tool Action type Implementation method and tool	is needed for…	Lean phase
Person	is responsible for…	Analysis tool Action type
	takes part in…	
	knows about…	
Action type	eliminates…	Waste type
Person	trains…	Person
Analysis tool	identifies…	Waste type
Person	is part of…	Implementation "on the road"
Person Action type	Anchors through…	Implementation
Action type	supports…	Lean principle
Etc.		

Table 3. Main domains and elements for structural change modelling

Domain	
1st level elements	2nd level elements
A People/Person	
Management level	
Top management	Person A
Middle management	Person B
Project engineer	Person C
Department	Etc.
Product development	
Design	
Innovation management	
Sales	
Corporate function	
B Waste type	
Waiting	
Overproduction	
Etc.	
C Action type	
Standardization	Specific form A
Visualization	Etc.
Etc.	
D Lean principle	
Value	
Value stream	
Flow	
Pull	
Perfection	
E Analysis tool	
Interview	
Questionnaire	
Etc.	
F Execution of pilot LD project	
Project with cost center	
Corporate function	
Besides the job	
G Implementation	
Implementation method and tool	
Work instruction	
LD roadmap	
Target agreement	
LD agent	
Implementation "on the road"	
Naming internal responsible persons	
Building a core team	
Top management support	
Etc.	
H Lean phase	
Waste analysis	
Action definition	
Action realisation	
Implementation	

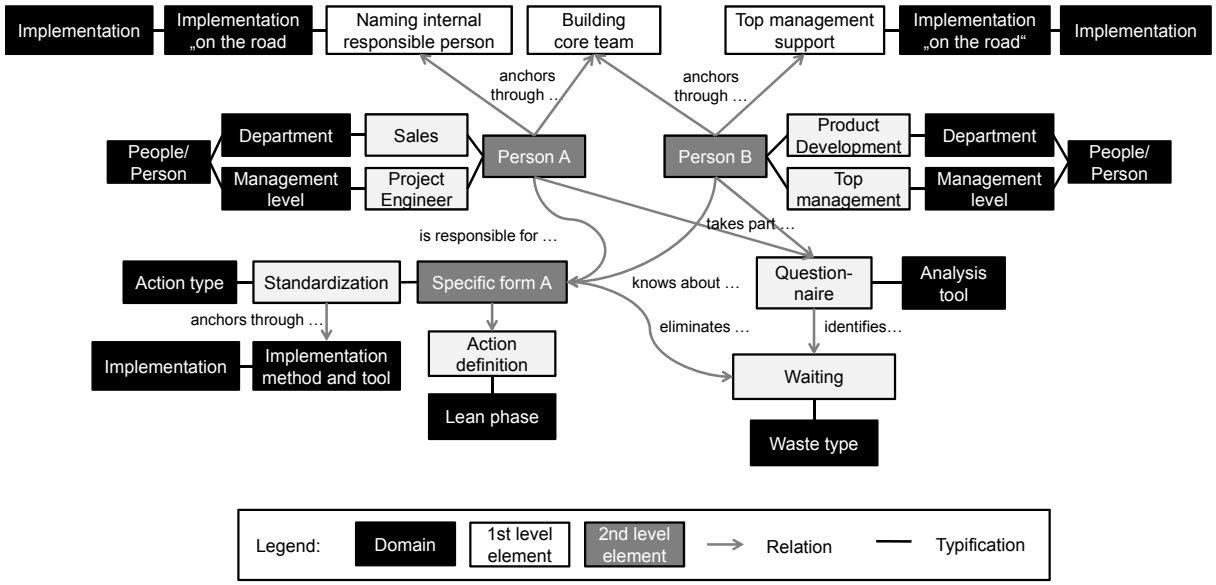

Figure 3. Example of a structural change model

4.4 Analysis of change models

Once the crucial situations during the LD transformation are interpreted, the models are analysed by means of structural analysis criteria, see section 4.2. In addition, these situations and the emergent patterns are analysed in detail with respect to three aspects – the development over time, attributes of the elements and the complexity of actions. Finally the findings are related to a company categorization to allow the formulation of the pilot schemes.

4.4.1 Structural analysis

As shown in section 2.2.3, different structural analysis criteria will be applied to the change models. The identification of clusters for example indicate whether certain elements of one or different domains interact commonly within the system. It further needs to be examined whether these clusters need to be resolved or not for the pilot scheme. Resolving could mean involving other people in the process, or to eliminate waste with the help of other actions. Emphasizing the cluster would mean identifying a leading lean responsible person or to follow one major action. The identification of active and passive elements helps to detect differences within one domain – person A is more active than person B, a specific action requires a lot of input, but contributes to just a few other elements.

4.4.2 Development over time

The previous section analyses each model at a specific time. To expand the examination, the model´s development over time is taken into consideration. Is a single element, e.g. a relevant person, to actively interact during the whole change process, or does he or she enter the process due to a certain interruption? Another question is whether elements belonging to a certain lean phase vanish over the time (are finished), or whether they continuously stay within the system. To get a first impression of the activity level of the change process as a whole, the observation sheet is organized chronologically equidistant. If a certain time interval is represented by the same length, it becomes clear in which time period activities are conducted and when intervals occur without interaction and activities. In addition, the causes of these differences and the reaction of the companies to overcome the situation are analysed.

4.4.3 Qualitative analysis of model

The domains and elements are additionally described by qualitative attributes. As mentioned above activities are differentiated into project logical and problem solving. Consequently, it matters whether a central element within a cluster belongs to the first or the second class. As part of a project logical

step, an element is integrated into the pilot scheme as a driver, whereas in the other case it needs to be considered as an obstacle. Furthermore, the attribute can indicate a quality such as feedback, discussion or examination. The more active a company examines tasks and actions by itself, the more probable its success in the implementation of LD. According to the self-help approach, the pilot scheme needs to activate companies to push the project by themselves and to manage as many improvements as possible internally.

4.4.4 Complexity of waste and action types

The structural analysis is applied on all defined domains. Nevertheless, the actions are the key elements for waste elimination. Since all companies suffer from different types of waste and hence develop different actions, it is necessary to have a look at the specific waste and action complexity. Some waste types can be too complex to be eliminated by a single action type. Moreover, an action type can be divided into sub-actions. This approach supports the quick wins. The realization of a certain action could fail whereas another runs without problems. This can apply within a company or when comparing different companies. The results indicate whether an action is too challenging in terms of number of involved persons, novelty of sub-actions or duration. E.g. a company with no experience in LD better implements numerous, but smaller actions instead of one major action. For the pilot scheme important levers for different types of companies need to be identified.

4.4.5 Combination of findings with company categorization, lean background and change capability

The findings of the precedent analysis steps are finally related with the identification aspects of figure 1. The main aspect is the company characterization that has been generated in the LD context [Helten et al. 2011]. Once relevant patterns could be found for one single company, comparable situations in the other companies are modelled to evaluate the type of pattern. The same situation could lead to an interruption in one company, whereas it's overcoming pushes the process in another company.

5. Discussion

As mentioned in 4.2, the first draft of the meta-model must be validated within a process of continuous comparison between the first drafts of model and analysis. The specific models must represent the challenges and key findings from the change process in that specific LD situation. Apart from the domains that strongly relate to LD (see lean principles or waste types) further domains as well as types of relation need to be added. Especially input from psychology and sociology could lead to elements regarding motivation or lean and change expertise.

Since the main goal of the modelling is the generation of different pilot schemes, the models must allow for the identification of similarities and differences within the companies. This allows the formulation of main structural change patterns and mechanisms. So far the research does not give a clear proof of the appropriate abstraction levels to do so. E.g. in some cases the structure seems more meaningful on the level of "Person A" and "Person B", in others a clearer picture can be gained by looking at the management or departmental level.

Apart from the internal validation by the authors, main situations need a validation by the industrial partners. Even though the researchers worked closely with the partners, misunderstandings can occur. The LD implementation ends with a final project review within all companies which includes the formulation of an LD roadmap. The discussion addresses the employees´ perception of important situations, phases as well as tools and actions. With the help of this feedback, the positive or negative interpretation of a pattern as mentioned in 4.2 is confirmed or rejected.

6. Conclusion and outlook

In order to support the implementation process of LD, the authors propose the use of pilot projects. A basic pilot scheme is developed which includes four necessary phases (analysis, synthesis, realization and implementation). To integrate the complex patterns that underlie the change processes during the LD transformation, a structural modelling and analysis approach is proposed. Based on literature and

experiences in industry, the authors decided on a meta-model consisting at the moment of eight domains and 15 relation types. The most important domains are people/person, waste type, action type, analysis tool and implementation. As types of relation e.g. the following can be mentioned: “is responsible”, “takes part”, “eliminates”, “identifies” and “anchors through”. The structural analysis will consider criteria like activity/passivity, cluster and leaf or bridge elements and will connect them to the interpretation and evaluation of relevant situations. The findings within three companies that are accompanied during the LD implementation are then connected to the aspects company characterization, lean background and change capability to generate different pilot schemes. It has to be identified whether the pilot schemes are derived from one generic scheme which is added by specific advice, or whether completely different schemes are necessary.

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