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Exploring Approaches How to Measure a Lean Process

Christer Österman[1], Anders Fundin[2]

[1] Scania CV AB, TD, B062, SE-151 87 Södertälje, Sweden, christer.osterman@scania.com (corresponding author)
[2] Volvo Construction Equipment, RLA 308, SE-631 85 Eskilstuna, Sweden, anders.fundin@volvo.com

Purpose: The purpose of the research is to explore a practical method of measuring the implementation of lean in a process. The method will be based on examining the abilities of a group. At this scale the ability to work standardized and solve problems is important. These two abilities are dependent of each other and are fundamental for the group's ability to create a stable result. In this context the method of standardized work (SW) is define to be the methods used in a process to generate stable results. Problem solving (PS) is defined as the methods used to return a process to a condition where SW is possible.
Methodology / approach: The research is conducted in a multiple case study in four large global manufacturing companies. The order of the data collection is: Firstly, interviews with the individuals that are centrally responsible for overall implementation of lean in the organization. Secondly, observe the implementation of SW and PS at the group level. In total 7 groups have been studied and 19 respondents interviewed.
Findings: Results show that the central definition of the methods for *standardized work* does not by itself have a direct impact on success of implementation of SW at group level. The method of SW where similar on a general level in the different cases, but with varying levels of implementation at group level was applied. Results also show that key factors for a successful implementation of *standardized work* on group level are: Ownership of the process, Direct connection to result of process, Correct workload and Leader demand. Methods of PS at group level where dissimilar despite a superficially similar approach. The evaluation method used was successful in providing comparable results between the cases.
Research limitations: A limitation of this research is within the scale of the measurement, as it only examines the group level. The research is further limited to four companies and seven groups.
Originality/value of paper: This paper aims to fill a gap in the established measurement methods of lean, as it examines the abilities of SW and PS at the group level of a process. These abilities are often referred to as essential in lean theory. However, there has been little scholarly work in defining the methods of SW and PS or the key factors affecting the methods at an operational level.

Keywords: Lean, Performance measures, Problem solving, Standardized work, Stability

1 Introduction

Lean production has spread across the world the last few decades. Various organizations have tried to implement the tools and systems over the years, with mixed results (Emiliani and Stec, 2005). The definition of lean as a concept is not always clear, however. In his review of contemporary literature on lean, Pettersen (2009) concludes that:

"*There is no agreed upon definition of lean that could be found in the reviewed literature and the formulation of the overall purpose of the concept are divergent. Discomforting as this may seem for lean proponents, there seems to be quite good agreement on the characteristics that define the concept, leading to the conclusion that the concept (lean) is defined in operational terms alone*".

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The methods used to measure the application of lean are equally diverse. However, there are several indicators and methods being proposed. A common approach are ways of measuring value flow and waste as popularized by the book "Learning to see" by Rother (1999). Another way of evaluating is to measure the application of lean methods. This can be done with, for example, an assessment system following a graded checklist were the application of different methods are assumed to lead to a more efficient process (Bhasin, 2011).

One commonly used assessment model is developed by Karlsson and Åhlström (1996); the researchers operationalize principles of lean production by identifying nine variables of lean implementation. These variables are of importance as they give a review of the progress in introducing lean production from both a Managers and a Strategy perspective. In this they assume an implicit connection between lean production and enhanced performance (Karlsson, 1996). In the challenge of measuring lean, there are also methods that consider more holistic perspectives, such as Dynamic multi Dimensional Performance (Bhasin, 2008), while the method derived from the research work by Karlsson and Åhlström (1996) can be used either with a systems perspective or with a top down approach.

With the purpose of complementing previous research, current study aims to evaluate a method that also is able on an *operational* level. The method is tested through case studies to ensure that the results are comparable and can be analyzed to find patterns and key factors.

The idea of a method for evaluation on an operational level is based on the actual application of fundamental methods of lean. Common for most lean implementation is the attempt to continuously improve (Monden, 2012; Wilson, 2010). In order to successfully do so, there has to be a stable situation from which to improve. Using the words by Jeffrey Liker, "*One must standardize, and thus stabilize the process, before continuous improvements can be made*" (Liker, 2004). In line with Liker, Rother (2010) put forward that , "*If a process is not stable, you will need to address this before trying to make other improvements, because without a stable process, further improvements will not stick"*(Rother, 2010).

Based on above reasoning, one of the most common methods used to achieve stability in a process is in this current study referred to as *Standardized Work* (SW), see for example Liker and Meier (2007). The main method used to respond to process variation is here referred to as *Problem Solving* (PS) The connection between the two methods is explored in the book *The evolution of a manufacturing system at Toyota* (Fujimoto, 1999), where the ability to solve problems at all levels is connected to the ability to create and follow standardized operating procedures.

Hence, as a mean to further explore lean evaluation methods on operational level, the research questions explored in this paper are:

1. How can methods of PS and SW be applied to measure lean in a process?
2. What key factors have impact on the success of the application of SW and PS in a lean process?

2 Theoretical framework

SW and PS have to be defined in operational terms. Therefore three different perspectives are examined in describing how a group operates. The individuals contribution to the results of a process is fundamental (Liker and Meier, 2007). Developing the skill and commitment of individuals and at the same time promoting group work and effectiveness are keys to success. According to Liker, "*Excellent individual performers are required to make up teams that excel"*(Liker, 2004). In line with Liker, but with other words, Taichi Ohno uses the analogy of a boat rowed by eight men to explain the connection between individual effort and group performance (Ohno, 2013).

Equally emphasized is the role of a proper leadership in lean, see Liker (2004). Developing people and groups is one of the leaders primary tasks (Liker and Hoseus, 2008). Therefore, a leadership perspective is added to the perspectives of the individual and the organization. Hence, three perspectives are considered.

- *The Individual* within the group. The methods and conditions necessary for an individual to perform well within a group.
- *The Organization*. How individuals in a group work together.
- *The Leadership* of a group. How you train and support people.

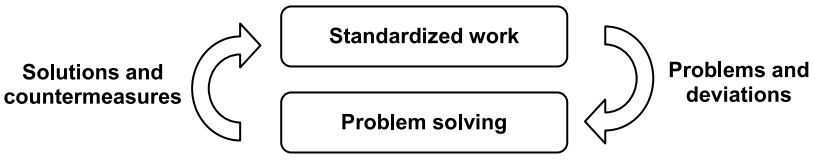

Figure 1: Connection between Standardized work and Problem solving

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A further factor that has to be considered together with the three perspectives above, is the connection between the methods of SW and PS. The following model is proposed, see Figure 1.

The purpose of SW is to provide a collection of methods to assure safety and reliability of a process. The term *Standardized Work* can be misleading when mixed-up with the term *Standard*. Standard is here defined as a specific method within SW.

PS is in the current study defined as the methods used to return a process to a condition were SW is possible if there is a problem or the process is unstable (Liker and Hoseus, 2008).

3 Research methodology

The following chapter describes the how the case study protocol is designed, as well as contextual considerations. Before the main study, a pilot study was conducted in order to verify the case study protocol.

3.1 Design of the case study protocol

A particular problem when designing the protocol is how to handle lean "jargon". The case study protocol is therefore based on the *purpose* of SW and PS. This provides general questions applicable in any process working with lean. The definition of the *purpose* and the subsequent formulation of the questions used in the case study protocol, are derived from first author's 11 years of experience in the application of lean as well as from theory.

The questions are then grouped accordingly:

1. Methods that are directly connected to how the Individual within the group performs a certain task in SW or PS.
2. Methods that are connected to how SW and PS is Organized within the group.
3. Methods that are connected to group Leadership.

Although there is a number of papers and books describing SW and PS on a theoretical level, very little scholarly work capture the details of the methods. This is a problem addressed by Olivella et al. (2007), "*LP [Lean production] theory has mostly been spread by the publication of Monden (1983), Ohno (1988) and Womack et al. (1990), whereas LP practices have been diffused by former Toyota engineers."(Olivella et al., 2007)*.

The questions are further divided into aspects, to ensure that the answers are possible to compare between cases. Aspects are defined to be specific parts of the methods for SW and PS. In the case study protocol these aspects are based on experience of the first authors in the application of SW and PS as well as existing audit protocols. This gives the cases a common reference to ensure comparability. These aspects are intended to be answered with Yes, No or Not Applicable ("-") if the aspect was irrelevant in that particular case, see Table 1.

3.2 Contextual considerations

The main focus of the study is on the *application* of the structure for standardized work and problem solving methods at group level, as it is defined by the lean support function, see Figure 2.

Application is defined as: The method that is used by the group for SW and PS.

Use is defined as: The usage of the information described *in* the method.

The study used to verify the measurement method is based on four large Swedish companies. The cases are anonymised for the confidentiality of the participating companies and people, as suggested by (Yin, 2009), and will be

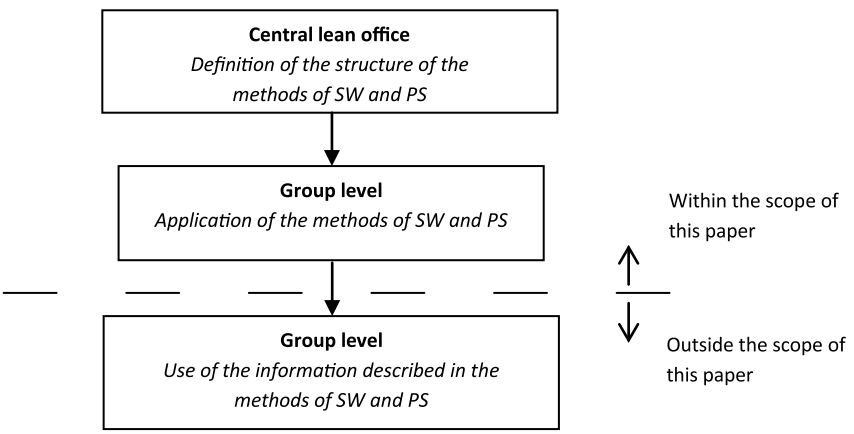

Figure 2: Contextual considerations: Application and use

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further introduced in the data section below as Case A, B, C and D.

The study is a multiple case study, as defined by Yin (2009), with a mixed methods approach inspired by Creswell (2009). Moreover, as suggested by Yin (2009), the underlying methods of SW and PS were organized in a case study protocol to ensure reliability and to provide a quantitative approach. Data was collected using observation of the application of SW and PS on the group level. The case study protocol was also used for semi structured interviews, see Bryman (2008), in which the people working in the process are asked to exemplify how the application of SW and PS worked within their context. The answers given were written as a comment directly linked with the aspect.

In all cases in the process, every person that was interviewed in the groups was asked to exemplify and show real cases of the application of SW and PS within their process to ensure the validity of the answers. All standards and problem solving methods observed were real standards used in production and real problems that had been solved by the groups. The examples are evaluated based on first author's experience of the topic. This, in accordance with Yin (2009), is a skill required by a case study investigator in which the investigator not only records the answers but also interprets them.

Using a case approach as suggested by Yin (2009), the cases are selected as a means to give variation of factors of production with two process companies and two manufacturing companies with significantly different products. None of the companies are in direct competition. The cases are similar as they are proficient in lean with 3-20 years of experience. Furthermore, the cases are large enough so that they have a need of a central lean office, which is a support function with the purpose of developing methods and competence in lean for the organization.

3.3 Pilot study

A pilot study was conducted to verify the questions, scale, method and structure of the case study protocol (Yin, 2009) The pilot study was conducted in stages using two separate, but sequentially connected, groups in Case C. These groups are not connected to the ones used in the main study (see group C1 and C2 below).

3.4 Cases

Case A is part of a large international Business to Business company specialized in material processing. Two groups working in different independent processes were studied at case A and will henceforth be referred to as group A1 and A2. The following people were interviewed: A manager in the central lean office, one second level manager, three first level managers and three operators.

Case B is part of a large group of companies controlled by a central headquarter. Case B is a Business to Business food processing facility. The products are mainly sold to stores or other companies in Sweden. Two groups working in parallel processes were studied at Case B and will henceforth be referred to as group B1 and B2. The following people were interviewed: A manager of the lean office of the plant, one first line manager and two group leaders.

Case C is an international Business to Business and Business to Consumers manufacturing company. Two groups working in different non connected processes were studied at case C and will henceforth be referred to as Group C1 and C2. The following people were interviewed: A manager of the central lean office, one first line manager, two group leaders and one technician.

Case D is a heavy equipment manufacturing company. The products are sold Business to Business and Business to Consumers. One group was studied at Case D and it will henceforth be referred to as Group D1. The following people were interviewed: A manager of the lean office of the plant and one first level manager.

In all cases a manager for the central lean office was interviewed first to record a definition of the lean system of the company. This was used to understand the application of the lean system in the groups. Even if the people involved in the case studies do not have equal positions in the different cases, all respondents seem to be familiar with the application of SW and PS in their own groups. Hence, the cases seem to be comparable even though the answers came from different sources within each company.

4 Findings from the empirical investigation

Findings from the empirical investigation are summarized, see Table 1. The table shows all case study protocols; the protocol is specified in the three columns to the left.

4.1 Different levels of standardization

SW I 1 and SW I 2 have been found to have different levels when comparing the cases, see Table 2. Multiple second level documents were typically connected to one first level document detailing every step of the work sequence.

The process industries (Case A and B) have only one level of standardized work with essentially only "What" and "How" descriptions. Only one group (Group A1) has some description of "Why" and the description was not well-defined. The manufacturing companies (Case C and D) both have two levels of SW.

The SW within the process industries were machine centric and connected to the places on the equipment on which the tasks where to be performed. The SW of the man-

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Table 1: Case study protocol and empirical findings

Y: Aspect used in that method **N**: Aspect not used in that method **»-«** Not applicable in that case,
SW= Standardized Work, **PS**= Problem Solving, **I**= Individual, **O**= Organizational, **L**= Leadership.

Note: *SW I 1* ***Con to meth****.= Connection to method,* ***Acc time/var*** *= Accumulated time per variant*
SW O 2 ***System****= There is a system for rebalancing work between positions*
SW O 2 ***Range****= Does there exists limits in which to balance work between positions?*
SW O 4 **Involved**= The response of the assisting function. They can directly help with the process or try to solve the problem or both.
PS I 5 **Assign res** = Is there a formal way of assigning resources to implement the solution?
PS O 1 **Previous att**.= Is there a record of previous attempts to solve the problem?
PS L 4 **Res. follow up**= Are the results of the PS followed up?

Case study protocols			**Case A**		**Case B**		**Case C**		**Case D**
Group			**A1**	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**
SW	**Questions**	**Aspects**							
SW I 1	How do I know *what* to do and in what *order*?	Job name	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
		Work sequence	**Y**	**Y**	-	-	**Y**	**Y**	**Y**
		Variant info	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
		Con to meth.	**-**	-	-	- .	**Y**	**Y**	**Y**
		Time	N	N	**Y**	N	N	N	**Y**
		Acc time/var	N	N	-	-	N	**Y**	**Y**
		Safety info	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	Y
		Ergonomic info	**Y**	**Y**	**Y**	N	N	**Y**	Y
		Assignor	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	Y
		Revision	**Y**	**Y**	**Y**	**Y**	**Y**	N	Y
		Date	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	Y
SW I 2	How do I know *how* to do my job?	Method name	-	-	-	-	**Y**	**Y**	**Y**
		What	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
		How	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
		Why	**Y**	N	N	N	**Y**	**Y**	**Y**
		Illustration	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
		Time	N	N	**Y**	N	N	N	**Y**
		Ergonomic info	N	N	N	-	**Y**	**Y**	**Y**
		Safety equipm.	**Y**	N	**Y**	**-**	**Y**	**Y**	**Y**
		Assignor	N	N	**Y**	-	**Y**	**Y**	**Y**
		Revision	N	N	**Y**	-	**Y**	**Y**	**Y**
		Deviation log	**Y**	N	**Y**	-	N	N	**Y**
SW I 3	How do I *organize* my work?	Get/remove	**Y**	**Y**	-	**Y**	Y	Y	Y
		Systemization	**Y**	**Y**	-	**Y**	Y	Y	Y
		Maintenance	**Y**	**Y**	-	-	Y	Y	Y
		Standardization	**Y**	**Y**	-	Y	Y	Y	Y
		Sustain	**Y**	**Y**	-	Y	Y	Y	Y
SW I 4	How do I know if I need to *call for help*?	Definition of Takt	**Y**	**Y**	-	-	Y	Y	Y
		Takt gives ref	**Y**	**Y**	-	-	Y	Y	Y
		Availability of ref	**Y**	**Y**	-	-	Y	Y	Y
SW O 1	How do we create *stability*?	Mix of tasks	Y	Y	**Y**	**Y**	**Y**	**Y**	**Y**
		Process buffer	Y	Y	-	-	**Y**	**Y**	N
		+/- people	Y	**Y**	-	**Y**	**Y**	**Y**	N

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Table 1 (continued)

Case study protocols			**Case A**		**Case B**		**Case C**		**Case D**
Group			**A1**	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**
SW	**Questions**	**Aspects**							
SW O 2	*Who does what* and how do we *avoid overburdening*?	System Range	N N	N N	- -	- -	Y Y	Y Y	Y Y
SW O 3	*Who knows what* and what is the *risk*?	Everyone noted Skill level Backup plan Training plan	**Y** **Y** N N	**Y** **Y** **Y** N	**Y** **Y** - **Y**	**Y** **Y** **Y** **Y**	N N N N	Y Y Y Y	Y Y Y Y
SW O 4	How do we *return to normal* as soon as possible?	Call for Andon Response time Registration Involved	**Y** 10m-1Day **Y** Support functions	**Y** Minutes **Y** -	**Y** Seconds N Help	**Y** Seconds N Help	**Y** Seconds Y Help/ probl solve	**Y** Seconds **Y** Help	**Y** 30 Seconds **Y** Help/ probl solve
SW O 5	*What is happening* and where are we *heading*?	Info collected Frequency Evaluate Decisions Priorities	**Y** Every list run **Y** **Y** **Y**	**Y** 3x/shift N N N	**Y** 1/shift **Y** **Y** -	**Y** 1/h **Y** **Y** **Y**	Y 4/d **Y** **Y** **Y**	**Y** 4/d **Y** **Y** **Y**	**Y** Shiftstart **Y** **Y** **Y**
SW L 1	How do I know what to check and how do I find time to do it?	Check planned Check done Check method Result noted	**Y** **Y** **Y** **Y**	**Y** **Y** N **Y**	**Y** **Y** **Y** **Y**	N **Y** N N	Y Y Y Y	Y Y Y Y	Y Y Y Y
SW L 2	How do I make sure that everyone is able to do their *job* at the *right level*?	Training plan Resources New or replace Followed up	Y Y Y **Y**	**Y** N N **Y**	**Y** **Y** **Y** **Y**	**Y** **Y** **Y** **Y**	Y Y Y Y	Y Y Y Y	Y Y Y Y
PS	**Questions**	**Aspects**							
PS I 1	What *conditions* are needed to succeed in problem solving?	Time Resources	**Y** **Y**	- -	**Y** **Y**	**Y** **Y**	- -	**Y** **Y**	**Y** **Y**
PS I 2	What has *happened*?	Problem label Date Description Consequence Assignor Affected Process System History Prev. attempt Illustration	**Y** **Y** N N **Y** N N N **Y** **Y** N	- - - - - - - - -. - -	**Y** **Y** **Y** **Y** **Y** N N N N N N	**Y** **Y** **Y** **Y** **Y** **Y** **Y** **Y** N N **Y**	**Y** **Y** **Y** **Y** N **Y** N N N N N	**Y** N N N **Y** N N N N **Y** N	- **Y** **Y** **Y** **Y** **Y** **Y** N **Y** **Y** **Y**

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Table 1 (continued)

Case study protocols			**Case A**		**Case B**		**Case C**		**Case D**
Group			**A1**	**A2**	**B1**	**B2**	**C1**	**C2**	**D1**
SW	**Questions**	**Aspects**							
PS I 3	How do we *quantify and define* the problem?	Categories Point of occurrence	**Y** **Y**	- -	**Y** N	**Y** **Y**	**Y** N	**Y** N	**Y** N
PS I 4	What is the *cause* of the problem?	Cause & effect Validation	N N	- -	**Y** **Y**	**Y** **Y**	**Y** **Y**	**Y** N	**Y** N
PS I 5	What can we *do about* it?	Solution space Choose alt. Impl. plan Assign res.	Y **Y** **Y** **Y**	- - - -	**-** - - -	**Y** **Y** **Y** **Y**	N N **Y** **Y**	N **Y** **Y.** **Y**	**Y** **Y** N N
PS I 6	Does the *solution* fix the problem?	Containment Short term Long term	**Y** N N	- - -	- - -	**Y** N N	**Y** **Y** **Y**	**Y** **Y** **Y**	N N N
PS I 7	How do we *implement* the new method?	Change meth. Change supp. Communicate Phys change	Y **Y** **Y** **Y**	- . - . - -	**Y** **Y** **Y** **Y**	**Y** **Y** **Y** **Y**	Y Y Y Y	Y Y Y Y	Y Y Y Y
PS O 1	Is the method *adaptable*?	Adapt meth. Nature of prob Avail. resou. Reoccurrence Previous att.	N N N N N	- . - - . - - .	**Y** **Y** **Y** **Y** N	**Y** **Y** **Y** **Y** N	N N N N N	**Y** Y Y Y Y	Y Y Y Y Y
PS O 2	Do we have a *history*?	Presentation Decision meet Priority History	N N N N	- - - -	**Y** **Y** **Y** **Y**	**Y** **Y** **Y** **Y**	N N N N	**Y** **Y** **Y** **Y**	**Y** Y Y Y
PS L 1	What problem should we work with?	Is it a problem Important Ability Resources	**Y** **Y** N **Y**	- - - -	**Y** **Y** **Y** Y	Y Y Y Y	**Y** **Y** **Y** -	**Y** **Y** **Y** **Y**	**Y** **Y** **Y** **Y**
PS L 2	Do we have people with the ability to solve problems?	Training system Trainers Certification	N N N	- - -	**Y** **Y** **Y**	**Y** **Y** **Y**	N N N	**Y** **Y** N	**Y** N **Y**
PS L 3	Do we have a way of transforming the solution into standardized work?	Comp. matrix Planning Temp q check Verification	N N N N	- - - -	**Y** **Y** **Y** **Y**	**Y** **Y** N N	N **Y** **Y** **Y**	**Y** **Y** **Y** **Y**	**Y** **Y** **Y** **Y**
PS L 4	Do we know that the problem is solved and will not come back?	Res. follow up Consequences Resource Lessons	**Y** **Y** N **Y**	-. - - -	N N N **Y**	**Y** **Y** N **Y**	Y N N **Y**	N **Y** N N	**Y** **Y** N **Y**

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Table 2: Levels of standardization

Standardization	Process industry	Manufacturing industry
Level 1	What , How	Sequence, What
Level 2		How, Why

ufacturing industries were position centric and connected to the work on a product that a person was to perform. The connection between SW and the final result of the process are therefore indirect in the process industries and direct in the manufacturing industries. Generally the observed work load / person are significantly lower in the process industries compared to the manufacturing industries.

4.2 Ownership

In the manufacturing industries the indicated sense of ownership of the SW by the groups is more evident than within the process industries. This is indicated by the fact that the "Why" description in (SW I 2) is more important and elaborated in the manufacturing industries; this is also confirmed in the discussions and interviews of the people in the processes.

4.3 The reference system

The reference system connects the demand of the customer to the performance of the group. The reference system of case A is not important for the group. If the equipment followed an intended pattern, it is found to be tolerable. In Case B, customer demand is not translated into a reference for the group. In Case B the end product was consumed in patterns over the year with seasonal high and low demands. Case C and D both have long lead times to the end customer but still translate the leveled demand of the customers into references available in real time.

4.4 Response time

As noted in SW O 4 the response when calling for support, was usually fast. The notable exception is Case A; the response time shows variation from a few minutes to a full working day. For Case C and D the sense of urgency is linked with higher workload and a real time reference (SW I 4) resulting in a quick response when a deviation occurred.

4.5 Training, support and frequency for follow-up

The inclination to use SW for training of employees and frequency for follow-up is more evident in Case C and D compared to Case A and B, were SW more seldom is used as a reference. The frequency for follow-up is seen as something important as it gives the organization the correct incentives and reinforced the importance of SW.

The differences in application seem to be mainly divided between the manufacturing companies and the process companies. Apart from the differences noted above, there are large similarities in how the cases have defines and applied standardized work. What is interesting here is that it seems to be independent of processes, preconditions, market demands and products.

4.6 Problem Solving

The pattern of difference between manufacturing and process companies does not follow through to PS. All cases, except Case A2, used different forms of *Five why* and *Ishikawa diagrams* as part of their problem solving methods but they used the methods in different ways. This is also true comparing groups within the same company. The exception (Case A2) stated that they did not use any method for problem solving. This is despite the fact that there are well defined methods within that company. Case B2 and Case D1 show the best structured and most supported methods. Both groups assigned time for problem solving on group level in a structured way.

However, none of the cases followed-up the amount of resources used during the problem solving activities and no conclusions were drawn regarding that. All groups allocated resources for PS except in Case A2 and C1 as indicated by PS I 1. No groups followed up the actual amount of resources used for the PS as indicated by PS L 4 and the understanding of problem solving methods seems to be different among the lean support functions in the four cases.

4.7 Analysis of the findings

Lean theory is clear on the importance of SW and the need to create stability in the process as a foundation for Continuous Improvement. Despite that most theory is vague in the specifics of how to operationalize SW, there was a remarkable consensus between the central lean support functions regarding general methods and definitions of SW in the different cases.

There is a notable difference in the level of detail in the work descriptions between the process industries and the manufacturing industries. This can be attributed to the fact that the quality of the result was directly linked with the manual labour being performed in the manufacturing industries whereas the SW of the process industries is more aimed at the needs of the process equipment and thus only had an indirect connection to the result of the process.

Lean theory is also clear on the importance of PS although there is a variation within the terminology used

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in the literature. In some theory, the emphasis is put on the endeavor to continuously improve the process. Other literature distinguishes between the effort to stabilize a process from the effort to improve and generate a new process. The theory is vague regarding the specific methods for PS regardless of the emphasis. The connection between PS and generating new SW is clear for all groups. The connection between not being able to follow SW, and thus having a problem, and PS methods are not evident in Cases A and B. It was more evident in Case C and D.

Finally, referring to ownership, PS in Case A and B are often managed by handing over the problem to a support function and by that also handing over the ownership of the problem. Case C and D indicated more of a sense of ownership and responsibility of the problem. What is interesting in these cases is that this sense of ownership remained even after asking for support.

5 Results

Referring back to the research questions, the following chapter provides the results from the research study.

5.1 Key factors

Even though each central lean support function spends considerable effort defining SW, the application of SW differed at the group level. Thus it can be concluded that a detailed definition of the methods for SW in itself was not enough to guarantee success in the application of SW at the group level.

Four key factors have been found to affect the application of SW on group level.

1. Ownership of the process
2. Leader demand
3. Correct workload
4. Proximity to the results of the process

According to observations and confirmation by direct questions, in Case A and B the responsibility for creating SW is mainly assigned to a support function. In Case C and D the sense of ownership for the SW is within the group. Ownership of the content of SW is assumed by the group and the details of "how" and "why" is more evident in the observed examples. Thus, it can be concluded that a group that assumes ownership of the method will be more successful in the application of SW than a group were the responsibility for the SW is delegated to a supporting function. This is also in line with contemporary lean theory, see (Liker, 2004). Frequency of following-up by process leaders on the details of SW can also be seen as contributing to a higher incentive in case C and D compared to case A and B. This is also in line with lean theory, see (Liker and Hoseus, 2008, Fujimoto, 1999).

The Workload per position is higher in Case C and D compared to Case A and B, making it important in Case C and D to specify a detailed description of SW, giving a higher sense of ownership. The Proximity to the process result seems to be more important for individuals working in Case C and D as they directly create the result of the process compared to Case A and B. Neither workload nor proximity to results are found as key factors when reviewing previous research.

With regards to PS the key factors are more difficult to distinguish. Based on Group B2, a structured method is in place and the leader of that group could provide evident examples of successful application of a PS method. The important factors in B2 are: Dedicated resources for the PS, Deep training in the method of PS and Leader support.

This is supported by the discussions within Group C2 and D1, however, further case studies are needed to verify this.

5.2 Method of evaluation of SW and PS on group level

The purpose of the method of evaluation of SW and PS at group level is to operationalize a method with which one would be able to reliably compare different processes. Formulating the questions of the case study protocol based on the purpose of the methods for SW and PS proved to be fruitful. Even though the cases are different, both in process and purpose, the common denominator is to understand how work is performed by individuals and how the work is organized and managed.

The key factors determining the success of implementation of SW and PS on group level are not directly exposed through the questions of each case study protocol, but are revealed through the comparison between the cases and through the answers from respondents in the interviews. Key factors proposed in current paper will have to be further verified in future studies however.

The inclusion of aspects to further detail the questions was successful as it gave a fine-tuned resolution of the case studies. The aspects ensured that the same details were observed in all cases and these acted as the lowest common denominators in the case study protocols. Thus it can be concluded that the proposed method might be used as a complement to the methods proposed by Rother (1999), Karlsson and Åhlström (1996) and Bhasin (2011) as it provides an operational perspective on a process.

6 Future research

Current exploratory multiple case study aims to examine *what* defines SW and PS methods and how it is *applied* on the group level of companies. However, the results and

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findings so far are one dimensional only. The case study protocol will have to be further revised and expanded to give a more multidimensional view of the application of SW and PS within a process.

In order to do so, the following matrix is proposed where the "What" column is covered in current paper and future research suggests studies covering "How" and "Why", see Table 3.

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Table 3: Future research

	WHAT	HOW	WHY
Individual	Defining methods for SW and PS used mainly for the generation of results of the process.	Observing how the defined methods for SW and PS for individuals are used in the active process.	Understanding the underlying attitudes of the individuals using SW and PS in a process.
Organizational	Defining methods for SW and PS used for organizing the work and information of the process.	Observing how the methods for the organization of SW and PS are used.	Understanding the underlying values that connect leaders and individuals within a process.
Leadership	Defining methods used for leading people and groups within SW and PS.	Observing how the defined methods are used by the leaders of the process.	Understanding the principles and values that govern the leadership behavior in SW and PS.

Note: »What«, »How« and »Why« are not the same as those defined in SW I 1 and SW I 2 in Table 1. In this table, these are linked with exploring more dimensions of the measurement method as such.

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Christer Österman is working as a Lean manager at the Global Lean office at Scania Trucks Sweden where he for over a decade has been involved in the continuous development of the Scania Production System. He is also an Industrial PhD Student at Innofacture research school at Mälardalen University in Eskilstuna, Sweden. His research focus is concentrated around the implementation of Lean production systems in various organizations. He holds a Master of Science and Engineering degree from the faculty of Industrial Production at Kungliga Tekniska Högskolan in Stockholm.

Anders Fundin is Global Manager Continuous Improvement at Volvo Construction Equipment and Adjunct Professor in Quality Technology and Management at the School of Innovation and Design at Mälardalen University, Sweden. He holds his PhD degree in Quality Technology and Management from Chalmers University of Technology. His research interests are related to quality management, operational development, lean production systems and customer feedback systems and their connection to product and service development within manufacturing industries.

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