CHALMERS

Increased usage of standardized work instructions

Development of recommendations for Autoliv Sweden AB

Master of Science Thesis in the Master Degree Programme, Production Engineering

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ABSTRACT

This master's thesis is based on a method including interviews and a workshop performed at Autoliv Sweden AB ´s production facility in Vårgårda. The method also includes a contrast study carried out at Scania, IAC and Saab, which all are distinguished companies in the field of standardized work instructions.

Autoliv Sweden AB is a manufacturing company that produces safety systems for automotive manufactures around the world. In the production facility, standardized work instructions have been implemented. However, they are not put to correct use, resulting in a production output that varies.

Operators perform work tasks differently and thereby do not follow standardized work instructions. The first reason for this is the nonfunctioning system when educating operators in new work task procedures. The second reason why standardized work instructions are not fully used is due to the limited follow-up concerning if operators work according to standardized work instructions. The third reason is because operators are not involved in the development of standardized work instructions which result in low motivation to work according to them.

Autoliv Sweden AB wants to use a visualization system to facilitate for operators to practice their work tasks in a correct procedure at work stations. The use of a visualization system is discussed and evaluated in this master's thesis as well as how to prevent the three reasons for not using standardized work instructions. This has resulted in this master's thesis recommendations which will provide Autoliv Sweden AB with means to ensure that operators work according to standardized work instructions both today and in the future.

The recommendations developed in this master's thesis result in a training system for operators that are taught new work task procedures. They result in a system on how to perform follow-up regarding if standardized work instructions are used.

They result in a new method on how to visualize standardized work instructions as well as a system that includes operators in the development of the standardized work instructions.

Key words: Standardized work instructions, Follow-up, Personnel training and Involvement of personnel

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1 INTRODUCTION

This chapter is an introduction to this master's thesis. It presents the background, purpose and objective. It also provides the delimitations to give an understanding of the master's thesis's scope.

1.1 BACKGROUND

Autoliv Sweden AB is a worldwide leader in automotive safety systems. Their focus is to develop and manufacture safety systems for automotive manufacturers around the world. Autoliv Sweden AB is located in 29 countries and has 80 facilities spread out in these locations. They have ten technical centers with 21 test tracks in nine countries. Autoliv Sweden AB's mission is to provide their customers with high quality products with the goal of zero defects. Their goal is also to ensure a leveled production output and a more ergonomic work environment throughout the entire company. In order for them to achieve this, they continuously have to work towards improving the work task procedures in the company.

Autoliv Sweden AB´s aim is to have a lean and visual production and they have therefore implemented standardized work instructions within their manufacturing operations. The operators in the extent that is intended do not put these instructions to real use. Involvement of operators in the development of standardized work instructions has not been prioritized due to shortage of time and instead their focus has been to produce high quality products with low labor minutes per unit, LMPU. Another concern for Autoliv Sweden AB is to keep their overhead cost as low as possible, which means the cost and support time required from white-collars to the production units. The overall aim is to be efficient and to minimize internal costs. This is partly done by a low LMPU and a low overhead cost.

For Autoliv Sweden AB to ensure a leveled production output and an ergonomic work place, operators need to work according to standardized work instructions at all times. Today the output number in the production lines varies due to that operators perform their work task in different ways and they do not work according to standardized work instructions. Autoliv Sweden AB wants to use a visualization system to prevent this from happening and to facilitate for operators to perform their work tasks according to standardized work instructions.

A reason why operators perform work tasks differently is the non-functioning system for educating identical work task procedures to operators. Today the operators are trained by different individuals who perform the work task in different manners. They use the standardized work instructions as a guideline in the training, but it is not emphasized enough that the operators should follow the work procedure exactly and cannot be trusted since the standardized work instructions are not always updated. Some of the instructions have a shortage of information regarding assembly sequence and work methods from an ergonomic view point. This results in operators who are taught varying work task procedures at the work stations.

Another possible reason why standardized work instructions are not used in the extent that was intended is the one year interval between follow-up to investigate if standardized work instructions are used among operators. Due to the long interval, it becomes difficult for Autoliv Sweden AB to ensure that standardized work instructions are used among operators and it also makes it difficult to ensure that the instructions are updated. As mentioned before, instructions that are not updated are a reason for the low degree of usage. If operators feel that standardized work instructions are obsolete and do not include all relevant information, they will not become motivated to work according to them.

Furthermore, there is a lack of involvement of operators in the work of developing standardized work instructions. This might also be a reason for the low motivation and unwillingness to follow standardized work instructions. A potential risk if operators do not understand the reason for following standardized work instructions is, operators who do not work according to them.

1.2 PURPOSE

The purpose of this master's thesis is to provide Autoliv Sweden AB with recommendations with means that ensure that operators work according to standardized work instructions. This is done to achieve Autoliv Sweden AB's vision of zero defects, a leveled production output and a more ergonomic work environment. A requirement of the means recommended to Autoliv Sweden AB is that the amount of time and effort put into supporting them is kept at a minimum. To narrow the scope of this master's thesis work the analysis is limited to a certain production cell and the recommended means are adjusted to this cell.

1.3 OBJECTIVES

The objectives of this master's thesis are:

- Recommend means on how to ensure that operators receive identical information when they are trained in new work task procedures according to standardized work instructions
- Recommend means on how, by whom, and when to perform follow-up regarding if standardized work instructions are followed by the operators
- Define and recommend what means to use to visualize standardized work regarding the assembly task sequence, as well as the appropriate working techniques from an ergonomic perspective
- Recommend how to involve operators in the development of standardized work instructions

1.4 DELIMITATIONS

The personnel at Autoliv Sweden AB will be able to use the information from this master's thesis as the foundation for a future strategy regarding the mentioned scope.

The scope of the master's thesis does not include how or in what order to implement the measures, nor will it include priorities on which measure that is most important. Another field excluded from this master's thesis is to decide what information Autoliv Sweden AB´s standardized work instructions should include. A third field that is excluded is how to create an understanding among operators of the importance of following standardized work instructions.

2 LITERATURE STUDY

This chapter includes the findings from the literature study. The findings will function as a support for the developed concepts, see chapter 5 *Concepts and evaluation, and the final recommendations, see chapter 6 Recommendations.*

2.1 STANDARDIZED WORK

According to Imai (2007) there exist two types of standards, one is managerial standards and the other is operational standards. The managerial standard is needed to manage administrative tasks such as, personnel guidelines, policies, job descriptions, administrative rules etc. The operational standard demonstrates the best and safest way of performing a job. They also ensure that the company maintains knowledge and expertise within the organization (Imai, 2007). When standards are implemented, it becomes possible to measure performance and also to visualize the relationship between an error and its cause. Without operational standards, it is almost impossible to follow-up problems and ensures that they are eliminated (Imai, 2007; de Treville, Antonakis & Edelson, 2005).

By standardizing work instructions and creating stable processes, continuous improvements can be made. Standardized work instructions shall, according to Liker (2004) include the time needed for operators to finish work requested by customers, takt time and it has to show the sequence when performing work. Freivalds and Niebel (2009) stress that the information needed to create standards is an outcome from performed time studies and work measurements. The results from these studies provide information on how to perform work tasks with consideration taken to takt time and the employees' work environment (Freivalds & Niebel, 2009). If a problem occurs within the manufacturing, the first thing checked is if the standards where followed (Liker, 2004).

Operators within the company receive benefits from using standardized work. The benefits are easier education and learning process of new operations. Monotones are reduced because they are able to shift between different work stations and lines (Productivity press development team, 2002). Standardized work makes it easier for operators to detect problems and contribute with improvement ideas (Productivity press development team, 2002).

Follow-up is an important step in the procedure of implementing new methods or assignments. This is because follow-up confirms that new methods are used and understood and if the goal for implementation is fulfilled or not (Freivalds & Niebel, 2009; Sörqvist, 2004). By performing follow-up, one investigates, at a regular basis, if employees work according to the standardized work instructions (Sörqvist, 2004). Follow-up should be performed every week to make sure that the instructions are updated and that the process is stable (Ortiz, 2006). If the result deviates from the instructions, measures have to be performed to ensure that everyone follows the decided work method (Sörqvist, 2004). Follow-up could also be the foundation for new ideas to be created because the field is always monitored and the motivation for improvements gets higher (Freivalds & Niebel, 2009; Ortiz, 2006). Wall (2005) stresses the importance of performing follow-up when a change has been made. This information should be communicated to employees so that they get involved in change process and so they are able to see how their contributions have affected the result.

Furthermore, Ortiz (2006) argues that operators should be involved in the continuous improvement work. This is because they are the experts of the work at line and they are the ones who can change the culture on the shop-floor. Ohno (1978) discuss the importance of people that writes standardized work instructions should be devoted to the work and understand the benefits it brings to implement them successfully.

The operators should perform the development of standardized work instructions, which will result in that the acceptance of working according to them will increase. When operators are involved in the development of standardized work instructions, they will be more satisfied with their work because they have an opportunity to affect their own situation (Liker, 2004; de Treville, Antonakis & Edelson, 2005; Ohno, 1978). de Treville, Antonakis and Edelson, (2005) also argue that it is very important to encourage employees to improve the standardized work instructions at all times; this is to increase their motivation. Imai (1986) also discuss that it is important to involve everyone within the organization in the improvement work due to that employee's work ethic is increased when they are able to identify problems and provide the company with solutions.

2.1.1 JOB MOTIVATION

How people within a company perform their job assignments depends on how motivated they are toward the assignment and also the willingness to help each other (Tonnquist, 2008). Other factors that are relevant are how driven they are to generate new ideas and the way they are communicating with each other. To motivate employees it is important to encourage them to share information and ideas and also encourage them to cooperate (Tonnquist, 2008). Furthermore, Aamodt (1999) stress that to increase motivation for a work task, goals should be created. These goals should be formulated so that they become concrete, reasonable and specific. The positive effect of this is that personnel increase their productivity and performance level because they have something to strive towards (Aamodt, 1999). To succeed with goals, feedback to the personnel is required. This is to provide them with information about how they are performing in relation to the set goals. Enhancement of performance is only reached when the feedback is positive and informative (Aamodt, 1999). Latham (2003) also discuss the importance of creating goals; this is because it gives people a direction to move towards.

By setting up goals, personnel are able to reduce the stress of not knowing how and why they are performing a work task.

When standardized work instructions are implemented, personnel often resist it until they become aware of the positive result they contribute with. When this barrier is broken down and standardization is implemented and accepted, it will increase job satisfaction and creativity among the personnel (Productivity press development team, 2002). This is due to that improvement work becomes a daily activity and personnel are the key factor for this to be successful, which provides them with self-esteem (Productivity press development team, 2002).

2.1.2 QUALITY

By establishing standardized work instructions, it becomes easy to evaluate the process and make sure that the work tasks are performed in the right quality level (Ortiz, 2006). For this to be successful, company policy needs to involve and respect the quality work. Responsibility areas has to be clear and procedures needs to be developed throughout the whole organization. Standards need to be followed and documentation has to be accurate to view operations and maintenance of every process (Bell, McBride & Wilson, 2002).

2.2 CHANGE

When a change occurs within an organization it is important to involve all personnel. By using a combination of a top-down approach with a bottom-up approach the personnel gets an opportunity to reflect upon their work tasks and the potential improvements. This is crucial for the improvement work due to that personnel are experts on the work tasks they are performing (Latham, 2003). If personnel are challenged to evolve and get own responsibility, their motivation will increase and they will perform at a higher level. It will also result in that they feel important to the company, which will be a driving force to improve their work (Latham, 2003). Wall (2005) stress that the way management communicates the change is important.

If they take proactive actions during the change and provide the personnel with a positive feeling, the result would be encouraging and the personnel would have a more positive attitude. Another important factor is to be honest and clear about the change, managers should explain the background to the change and the result that it will bring. Freivalds and Niebel (2009) argue that industrial engineers need to understand the psychological and sociological reactions from personnel when it comes to methods, standards and wage-payment. This is because humans have an ability to respond negatively towards change. The main reason why humans have an ability to resist change is due to that change indicates displeasure with the current situation. This result in that they defend the current situation because it is connected to their individual performance.

2.3 LEARNING AND ORGANIZATION CULTURE

Producing companies' focus is directed towards the phase of producing products rather than focusing on development of operators and their learning. This antagonism is usually based upon a lack of employees and it creates difficulties in educating new and experienced operators as well as participation in developing procedures during ordinary working hours. Especially in the later aspect there is a problem in finding enough time to document existing problems in the production process, to meet in groups for discussions and to follow-up identified problems (Ellström, 2009). Granberg (2004) writes similarly that methods as lean production, quality management and balanced scorecards, foster the difficulties individuals have to question and critically evaluate work tasks and company goals.

The basic condition for maintaining a well-functioning company, a learning organization, is according to Ellström (2009) developmental learning. Developmental learning is when the individuals question and try the approach to tasks and goals as well as they attempt to influence their work and life conditions.

This gives individuals an approach to handle complex situations and problems, where the main task is to not only create and make suggestions on how to solve problems, but rather to identify and define for what situation, task and problem it concerns.

In the industry today, there is a potential to use developmental learning, but this is not always exploited in the daily work in companies. There are at least two factors that act as limiting in this context: the organization's structure and the lack of time for educating employees (Ellström, 2009). Bengtsson and Berggren (2001) write about the relationship between lean production and learning. They argue that lean production, which usually is implemented to continuously improve and render production that is more efficient, simultaneously confine developmental learning.

2.4 SHARING INFORMATION

Information could be explained as the knowledge someone receives concerning a specific fact. In a more technical sense, it is the reduction of uncertainty regarding facts (Freivalds and Niebel, 2009).

Nonaka and Takeushi (1995) have developed a framework called the SECI model; see Figure 1, which is built on the knowledge-creation process of Japanese organizations. The model relates the spiraling knowledge creation within firms to four knowledge conversion processes: socialization, externalization, combination and internalization (Nonaka & Takeushi, 1995). The model is based on the perception that knowledge exists in two modes: tacit and explicit.

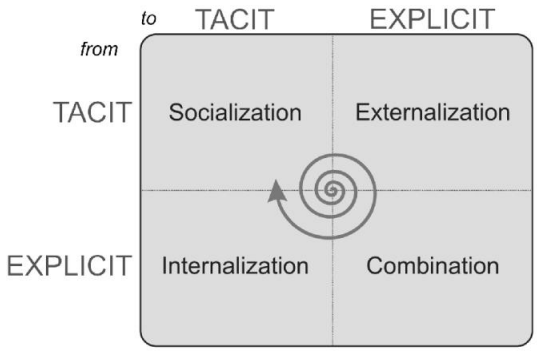

Figure 1: The SECI model (Carvalho & Ferreira, 2006)

2.4.1 SOCIALIZATION, SHARING INFORMATION THROUGH VOCATIONAL TRAINING

Socialization is the process of sharing tacit knowledge through shared experience. It could be the sharing of knowledge between the master and his or her apprentice, which is named on-the job training (de Carvalho & Ferreira, 2006).

Dreyfus and Dreyfus (1986) write about the ability to acquire knowledge from a vocational training angle. According to them there exists a five step model that demonstrates how knowledge for a profession is developed. These steps explain the amount of knowledge an individual have in relation to the knowledge required to manage the work task.

- Novice: Has no experience
- Initiate: Relates work with earlier experiences
- Competent: Work situation has developed an understanding regarding the knowledge
- Skilled: Relates work with earlier experiences and understands the similarities
- Expert: The knowledge is understood

Fitts and Posner (1967) also discuss how to acquire knowledge. They divide learning into three different phases. These phases are together called the motorical readiness curve. The first phase is the cognitive phase where individuals need to focus on the assignment and connect it to how the movement pattern should be performed to manage the work task. To create an effective learning, it is important that practical examples are demonstrated. This is done to create a deeper understanding for the person whom is learning the work task (Fitts & Posner, 1967). The second phase is called associative phase. In this phase the knowledge on how the work task should be performed is deepened and the person whom performs the work task is starting to manage the work procedure without having to focus on every detail connected to it.

The final phase is the autonomous phase. In this phase the person has reached a level where the work task is managed by a routine based acting, the person has gained tacit knowledge (Fitts & Posner, 1967).

Ortiz (2006) emphasizes the importance of never forcing employees to take part in education. When work tasks are forced on an individual the outcome can result in that the learning process is interrupted or blocked. It can result in that the individuals' learning is converted into resistance (Granberg, 2004).

Ortiz (2006) writes that education should include practical work on a training line where the employee is able to improve his or her skills before starting to work on the real assembly line. This will result in that productivity will be kept high within the real assembly line and also ensure that competence and skills of operators is high (Ortiz, 2006).

2.4.1 EXTERNALIZATION, PRESENTING INFORMATION THROUGH VISUALIZATION

Externalization is the process where tacit knowledge is articulated into explicit knowledge with the help of metaphors, standards and codes. This face is triggered by dialog and collective reflection (de Carvalho & Ferreira, 2006).

Digital technology is often implemented to enhance the access level of information, increase the information flow, and facilitate when decisions are being made (Winman & Rystedt, 2008). By presenting information through the digital world, it is possible to decrease the learning curve for operators (Gustavsson, 2008). According to Gustavsson (2008) this leads to a reduction of the implementation time of new lines in the production industries due to that operators need less time to learn new work procedures.

Information can be classified as static - the information does not change with time; or dynamic - the information does change with time (Freivalds and Niebel, 2009). Descriptive and depictive are two other terms to describe representation of information (Watson, Butterfield, Curran & Craig, 2009). Descriptive information has no similarity to the object it refers to and it is symbol-based, e.g. text, whereas depictive representations present information that is similar to the object it refers to, e.g. pictures (Watson, et al. 2009).

There are several empirical studies performed to investigate if visualization with static pictures or dynamic animations is most effective for learning. The outcome of the studies is an ambiguous matter according to Gerjets and Scheiter (2009). Watson et al. (2009) claims, that there is no significant difference in performance of assembly when using static diagrams compared to animations to display the information on how to assemble a novel device. Watson et al. (2009) claim that the time of assembling a novel device when using static diagrams or dynamic animations, depictive information, is considerably faster when assembling the first time than when using static text, descriptive information. This advantage is leveled the third time of assembling. Tversky, Morrison and Betrancourt (2001) have the opinion that efficiency of learning with animated graphics is less than for static graphics. They claim that animations might be less effective because they are too complex and fast to be accurately perceived. A potential risk with visualizing a complex task with animations and annotating texts is that it can overload the cognitive capacity of learners (Wouters, Paas & van Merriënbour, 2010).

These thoughts are not in line with the findings of Höffler and Leutner (2007) meta-analysis of 26 studies between 1973 and 2003. They claim that there is an overall advantage of learning with instructional animations over static pictures. There are a number of different reasons why depictive display of information is considered beneficial for learning according to Höffler & Leutner (2007).

When considering animations over static pictures, one reason might be that it helps when mentally visualizing a procedure, resulting in a cognitive load reduction compared to a situation where the procedure has to be reconstructed from a series of pictures (Höffler & Leutner, 2007). According to Gerjets and Scheiter (2009) the learning increases if help is provided to facilitate the gaining of information and understanding of visual complex system when learning through using animations.

2.4.2 COMBINATION AND INTERNALIZATION

Combination is the process of converting explicit knowledge into more explicit knowledge. It is done by telephone calls, e-mailing and adding information into a computer program (de Carvalho & Ferreira, 2006).

Internalization is the process where explicit knowledge is converted into tacit knowledge. This phase usually occurs when explicit knowledge is put into practice (de Carvalho & Ferreira, 2006).

2.5 INTERACTION BETWEEN OPERATOR AND TECHNOLOGY SYSTEMS

Knowledge of a person's cognitive processes is the key to understanding how decisions are made and why responding actions are taken (Eysneck, 1991). The link between cognitive processes and human-technology systems should be considered when deciding on what information source to use when visualizing standardized work instructions in an assembly line and how to train operators with new work task procedures.

2.5.1 COGNITIVE PROCESSES

Humans take information from their surroundings via their senses, ignore or pay attention to information, process information in their memory, make decisions and take action (Freivalds and Niebel, 2009). These are all cognitive processes that take place when people deal with information and they can be schematically showed in a model; see Figure 2 (Bridger, 2003).

The five big stages or components in the model of human information processing are: perception, decision and response selection, response execution, memory, and attention resources distributed over various stages (Bridger, 2003).

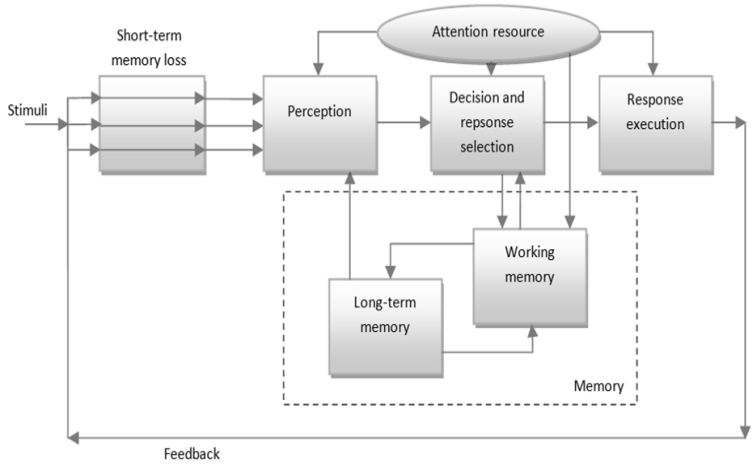

Figure 2: Wicken's general model of human information processing (Bridger, 2003)

2.5.2 PERCEPTION

Perception is the assessment of incoming stimuli, information from the surroundings, with already stored knowledge to sort out and categorize it (Freivalds and Niebel, 2009). Almost 80 % of all sensory impressions, perceptions, are detected via the eyes and the visual impression is the sensory that people rely on most (Osvalder & Ulfvengren, 2009). The human ability to detect visual stimuli and perceive it correctly is affected by previous experience, knowledge and expectation, and how the visual information is displayed (Osvalder & Ulfvengren, 2009).

2.5.3 ATTENTION

Attention is the amount of cognitive capacity devoted to allocating mental resources toward what is most important in the current situation (Freivalds and Niebel, 2009). There is a limit to the attention resources an individual has at one's disposal (Eysneck, 1991). The more an individual divide the attention, the lower the quality of her understanding of what is happening in the surroundings (Osvalder & Ulfvengren, 2009).

There are four factors according to Osvalder and Ulfvengren (2009) that determine the information chosen and the senses to be activated, the so called selective attention:

- How salient the signal is
- What the individual expects to happen
- The value of the information
- How much effort it takes to acquire the information

There are three factors according to Osvalder and Ulfvengren (2009) which control how easy or difficult it is to carry out parallel work tasks, the so called divided attention:

- Mental effort and resources demanded to carry out primary tasks.
- Structural similarity of resources, whether or not the tasks need activation of the same type of sensory response.
- Task management and switching between tasks.

2.5.4 MEMORY

Memory constitutes an important role to enable people to re-use previously gained experience at a later date. The memory system has the important role of encoding, storing and retrieving information (Osvalder & Ulfvengren, 2009). The evaluation of learning is performed by the use of a memory test (Eysneck, 1991). The memory is usually divided into short-term memory, STM, or the so called working memory and long-term memory, LTM (Osvalder & Ulfvengren, 2009).

The process of encoding memories from the short-term memory to the long-term memory has to be made actively since this is not something that happens automatically. Encoding is something that is affected by stress, distractions of various kind and other external factors (Osvalder & Ulfvengren, 2009).

The short-term memory is used to store temporary information and it is used to retain the interpretations of events that occur in our surroundings (Norman, 1977). It is the memory that is active when stimuli from the surroundings are processed and perceived (Osvalder & Ulfvengren, 2009). The short-term memory is limited in how much information as well as the length of time that information can be retained (Freivalds and Niebel, 2009). When learning with static or dynamic visualization, the capacity of the short-term memory is the limiting factor (Höffler & Leutner, 2007). When processing information the short-term memory can be disrupted, especially when an individual is under stress. This leads to a great risk of overloading the short-term memory with lost information as a result (Osvalder & Ulfvengren, 2009).

The long-term memory has almost an infinite capacity to store data and it is used as a storage place for individual's experiences (Norman, 1977). Once the data is stored it is saved for a lifetime, but the difficulty for people is to find the data when they are searching for it (Freivalds and Niebel, 2009). The data stored in the long-term memory is more dependent on meaning than on information. Success of storing data is dependent on how well it is linked up in the networks of the brain. This is why learning is slow, the information gained needs to be linked in the correct places (Osvalder & Ulfvengren, 2009).

Kuhlmann, Piel and Wolf's (2005) study on memory retrieval indicates that psychosocial stress damages individuals' memory retrieval. Schwabe and Wolf (2009) performed a study to investigate if the contexts where learning takes place and knowledge is tested are influencing factors for memory retrieval when the subjects are exposed to stress prior to testing. The study shows that the negative influence of stress on memory retrieval can be avoided if the context where learning takes place is the same as where the knowledge is tested, or memories are retrieved.

2.5.5 DECISION MAKING AND RESPONSE EXECUTION

To be able to design a good system for visualizing information, it is relevant to know what influencing aspects there are on individual's ability to make decisions and respond accordingly (Osvalder & Ulfvengren, 2009). Decision making is the process where people evaluate the possible alternatives and decide on a proper response execution (Freivalds and Niebel, 2009). Ellström (1996) mentions four response execution levels or action levels. These levels are:

- Level 1. Routine based
- Level 2. Rule based
- Level 3. Knowledge based
- Level 4. Reflection based actions

In level one, see Figure 3, the actions of individuals is automated and routine based. Actions, stored and preset, are performed according to stimuli from the context. The actions are based on tacit knowledge; they are intuitive and they require low attention (Ellström, 1996).

Figure 3: The interaction of individuals and the context. Level 1, Routine based

In level two, see Figure 4, the actions are based on a slightly more conscious level. They are usually based on rule of thumb and they require individual ability to identify and later interpret observations of actions as well as decide what rule to follow. One can say that condition A results in action B. The rules can be in the form of instructions, prior experience or problem solving in different situations (Ellström, 1996).

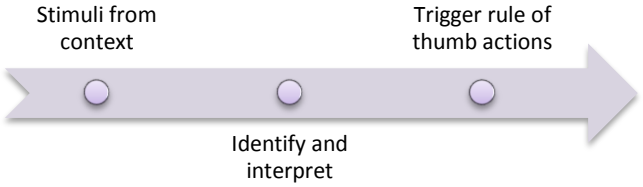

Figure 4: The interaction of individuals and the context. Level 2, Rule based

In level three, see Figure 5, the actions are controlled by conscious analytical thinking with the individual's goals, reflection of prior knowledge and knowledge of the context, in mind. Actions in this level are needed in new and unknown situations or when problem rise in familiar situations that cannot be solved with standard methods (Ellström, 1996).

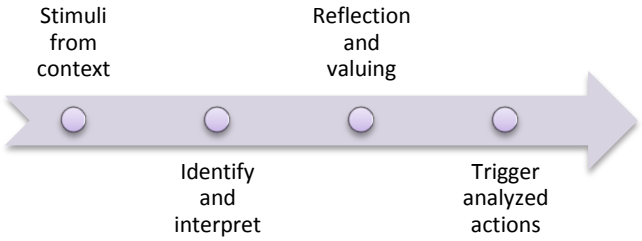

Figure 5: The interaction of individuals and the context. Level 3, Knowledge based

Actions in level four, see Figure 6, are based on an occurring reflection regarding the task in mind. The individual reflects on, if the executed tasks are performed in a correct way rather than if the correct tasks are being performed. This means that the actions are based on analyzing thoughts about the individuals' actions and the business' goals and policies (Ellström, 1996).

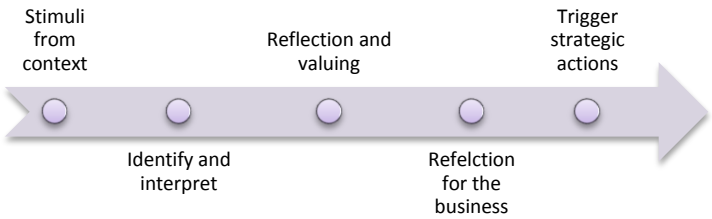

Figure 6: The interaction of individuals and the context. Level 4, Reflection based actions

3 METHOD AND REALIZATION

This chapter contains the method used during the work of this master's thesis. The realization of the methodology is shown in Figure 7.

This master's thesis is more of an engineering project than it is a research project. The method used is inspired by action research, but it does not fully correspond to it. This master's thesis procedures of action and evaluation are not equivalent to their counterparts in action research. The aim of action research is to both develop and change activities and at the same time develop knowledge about how this change is managed within a certain area of research (Rönnerman, 2004). Gustafsson (2008), states that action research involves learning and it includes individuals as part of a team in society. It is problem and future focused as well as context specific. It includes change with a focus on improvements and, it is a spiraling process where research, action and evaluation are connected.

The initial step of this master's thesis was to develop purpose and objectives that was relevant to the problem definition. These sections are the foundation of the master's thesis and the developed recommendations answer to the objectives. The next step was taken by gathering theory from relevant literature and collecting data from Autoliv Sweden AB. These are all measures similar to the action research method and they give a learning process, which is problem focused and context specific. An evaluation of the gained knowledge was made to ensure an adequate scope of the master's thesis. A deeper understanding in the relevant subjects was gained by further literature study and an execution of a contrast study, including interviews at three different companies. Another evaluation was made to ensure that the collected data was extensive enough and concepts were generated for the recommendations. A workshop together with employees at Autoliv Sweden AB was conducted to ensure that the developed concepts were realistic and in line with Autoliv Sweden AB's needs. These steps can be seen as an interpretation of the action as well as the

evaluation phase in action research. The next step was taken by finalizing recommendations. Discussion and conclusion were written and preparations for the presentation of the results were made. In the texts beneath, specific methods used will be described further.

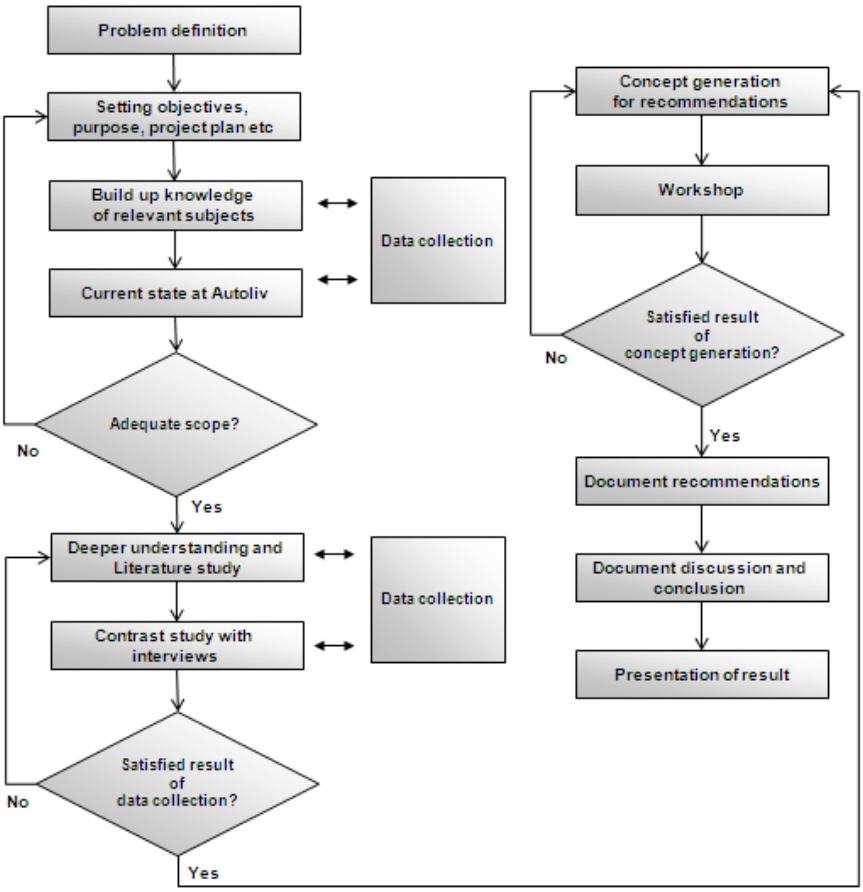

Figure 7: Research realization for this master's thesis

3.1 DATA COLLECTION

The recommendations in this master's thesis are based on data collection and interviews both at the company mainly in focus, Autoliv Sweden AB, and at other companies where a contrast study was carried out; see 3.3 Contrast study. To collect essential information and requirements from operators and engineers interviews were held, see 3.4 Interview. Another source of information, which served as a support to find concepts, were own observations and practical experience within all companies' manufacturing departments.

Relevant information from different literature sources also provided a support to the concepts and recommendations that were developed to Autoliv Sweden AB, see chapter 2 Literature study.

3.2 ADEQUATE SCOPE

To ensure that the objectives set from the projects beginning was adequate a discussion between the authors was held. Since more knowledge had been gained during the data collection the objectives were in this stage possible to narrow down and make even more precise and relevant for Autoliv Sweden AB's needs.

3.3 CONTRAST STUDY

A contrast study was carried out at Scania, IAC and Saab to observe their best practice regarding this master's thesis' objectives. Interviews have been held with one Production leader at Scania, two Improvement supports at Saab and one Business unit manager at IAC, see 3.4 Interview. Yin (1989) stress that the main advantage a contrast study provide is a deeper understanding of other companies' best practice and collection of data that otherwise had been inaccessible. Observations of other companies contribute with concrete information, because it is placed in a real world situation (Yin, 1989). Other sort of knowledge will also be gathered due to that observations provide visual information that is hard to collect from interviews.

3.4 INTERVIEW

The interview is the most basic way of collecting people's knowledge, experience, observations and opinions (Osvalder, Rose & Karlsson, 2009). Two different research approaches are qualitative and quantitative research. Quantitative research deals with quantified data, hard data or numbers, and it is treated as statistics. One pedagogical aspect of using quantitative research is that the information gathered could be used in diagrams and tables, which are easy to comprehend and grasp. It is important to remember that diagrams and tables need to be interpreted to have a meaning (Ejvegård, 2003).

Qualitative research deals with soft data, information that is impossible to use in numerical terms. It is information that describes the characterization of a word, artifact or phenomena (Ejvegård, 2003) Qualitative research generates hypothesizes and quantitative research has its focus on testing those hypothesizes or test the relationship between facts (Ryen, 2004).

Since this master's thesis' objective was to generate recommendations and to deal with characteristics of work methods, the obvious method to choose was the qualitative research method. One of the most used approaches in qualitative research is the interview, even though there are several others to choose from (Ryen, 2004). Interviews are usually divided into three categories: unstructured, semi-structured and structured interviews. Unstructured interviews are best when a qualitative data is sought for and structured or semi-structured interviews are best used when quantitative data is sought for (Osvalder, Rose & Karlsson, 2009). In this master's thesis the interviews has been conducted using an unstructured interview method. As the name calls for the unstructured interview is performed in a less structured way and the goal is to ask open questions so that the interviewee can express their answer freely with an open mind (Osvalder, Rose & Karlsson, 2009). This was a suitable method to choose since it gave an opportunity to use and explore the interviewee's full competence. The questions asked can be seen in chapter 4 Contrast study. A downside with this type of interview is that the data collected can be difficult to interpret and compare (Osvalder, Rose & Karlsson, 2009).

3.5 SATISFACTORY RESULTS OF DATA COLLECTION

To guarantee that the collected data was extensive enough a comparison was done between the gathered information and the objectives. Since the gathered material was believed to be significant enough the next step, concept generation, was taken.

3.6 CONCEPT GENERATION

The generation of concepts is based on the previously set objectives and, the theory and information gathered during the data collection period. Ideas were generated in a brainstorming session between the authors of the master's thesis. The concepts generated in the first draft where analyzed and combined into better and more detailed concepts. These were also discussed and further developed to create the finalized concepts, see chapter 5 Concepts and evaluation.

3.7 WORKSHOP

A workshop was held during the later stage of the development of concepts. It was held to get a deeper understanding of what criteria the employees at Autoliv Sweden AB thought was most important to consider, when deciding on which concepts that was most suitable and important to implement. In the workshop the level of realism and relevance of the developed concepts were also discussed. The participants were chosen from different hierarchy levels to get a wider perspective of the thoughts and ideas created in the workshop. The participants were four production process engineers, one operator and one group leader. The reason for why the brainstorming session only included two of the objectives was due to that these objectives require quite a lot of support and operator time. The goal of the objectives was to keep support and operator time at a minimum, so the amount of time Autoliv Sweden AB could provide these two objectives with was important for the outcome of the recommendations.

The method used in the workshop was inspired by a method called brainwriting or 3-6-5 method. According to Osvalder et al. (2009) brainwriting is a silent brainstorming where the participants write the answers to and thoughts of a question at a piece of paper. The workshop lasted for 90 minutes and the participants were not allowed to talk to each other during the time they answered the questions and in total there where two questions asked in two sessions, see Appendix E – Workshop.

Each participant started with giving two answers to a question on a piece of paper, during three minutes. The papers were then passed on to the next person who continued with adding one idea or thought to the previous persons answer. In the end of each session a discussion was held about the answers and the most important criteria to consider regarding the answers.

The thoughts and answers from the workshop where gathered into one matrix to give a clear overview of the information. This information was then used when selecting the best concepts for recommendation; see chapter 3.8 Satisfactory results of concept generation.

3.8 SATISFACTORY RESULTS OF CONCEPT GENERATION

The generated concepts were evaluated according to the information gathered in the workshop, see 3.7 Workshop, and the concepts were also compared to each other. An analysis was held to identify the most suitable concepts to recommend Autoliv Sweden AB, both for the present situation and to strive for in the future, see chapter 5 Concepts and Evaluation. In the analysis an evaluation table was used for the concepts 1A -1E, see Table 5 in chapter 5.1.6 Evaluations of concepts. The method used in the evaluation table is described in the following section.

3.8.1 EVALUATION TABLE

A Pugh matrix is a method that enables how to find a solution to a problem in a systematic manner (Lindstedt & Burenius, 2003). The Pugh matrix is not an objective method to use since it is based on the users' values. The solution that receives the highest total points in the table is the most suitable solution to use to solve the problem (Lindstedt & Burenius, 2003).

For evaluating concept 1A – 1E a Pugh matrix was used, see Table 5. It was used to find the best concept compared to the reference, which is the present situation at Autoliv Sweden AB. The criteria in the table are weighed in relation to each other, their importance for the final concept and then assigned with a relevant number.

The support time is considered to include time spent on the concept by production process engineers and other roles excluding operators. Operator time is the time spent on the concept by operators and mentors. The level of information is the possibility to keep the information taught to different operators static. The effectiveness of learning is how well the concept fosters learning. Each concept is judged by their qualifications in relation to how well it is answering to the criteria. In Table 5, chapter 5.1.6 Evaluation of concepts, the support time is considered the most important criteria and the rest of the criteria are considered as equally important correspondingly to this master's thesis work initiator at Autoliv Sweden AB, Mikael Kullingsjö. Therefore the support time criteria is weighted as twice as important as the rest of the criteria.

3.9 DOCUMENTATION

In the final stage of this master's thesis, documentation of the finalized recommendations, discussion and conclusion was completed. Preparation was made for the presentation at both Autoliv Sweden AB and Chalmers university of technology

4 CONTRAST STUDY

This chapter represents the information gathered from interviews executed in the contrast study. It includes how Scania, IAC and Saab ensure that operators that are trained with new work task procedures get identical information according to the existing work standards. It includes how the companies perform follow-up regarding if standardized work instructions are used and how the companies visualize standardized work instructions. It also includes how the companies involve operators in the work of creating and maintaining standardized work instructions. At last a discussion is held about the similarities and differences between Autoliv Sweden AB and the other three companies.

4.1 IDENTICAL INFORMATION DURING TRAINING

Table 1 composes a summary of the three companies' answers to questions regarding identical information during training. More detailed information is found in the following texts in this section.

Table 1: Table covering questions asked about teaching identical information during training

Identical information			
Company: / **Question:**	**Scania**	**IAC**	**Saab**
How do you educate new assemblers?	Three weeks introduction and taught by a mentor	Taught by the team leader	Taught by a mentor Knowledge test is performed Gained knowledge is connected to a competence matrix
Does a certain system exist to ensure that all assemblers receive the same education when they are new at a workstation?	Yes Follow standardized work instructions when teaching	Yes, standards are to be followed	Yes, mentors receive education Follow standardized work instructions when teaching

4.1.1 SCANIA

Assembly workers receive an introduction of three weeks where they are educated in ergonomics, the position standards and the tempo description, and how to develop standards.

They also get practical education at the line with help and support from a mentor. Here the assembly workers are educated according to the position standard and the tempo description. During education it is relevant to communicate the importance of following standards and to make sure that the assemblers understand that they are valuable to the company. There is a mentor, at each line, that is responsible for the new assembly worker during the introduction. If this person is not available the group coordinator takes this responsibility.

4.1.2 IAC

To train new assemblers, IAC use their team leader as a mentor. The mentor educates the new assembler on how to work according to standards. If the assembler has not learnt the work station in one week, he or she is not allowed to continue working. When they use temporary recruited people they do it the same way with the difference that the first eight hours of training are paid by the other company instead of by IAC.

4.1.3 SAAB

At Saab, new assemblers are educated according to SOS, standardized operation sheet, and JES, job element sheet, by a mentor. The new assemblers receive training at the station following each row in the SOS and the connected information in the JES. A number of rows in the SOS make out one step and for each passed step they receive a symbolic piece of a cake in a competence circle. When the operator have received all pieces in the circle, the production leader perform a follow-up to make sure that he or she works according to and understands the standards. The mentors are educated to make sure that they are capable of educating someone else and that they have high knowledge about standards. To ensure that the assemblers' knowledge is current they have to undergo a knowledge test about the SOS and JES.

4.2 FOLLOW-UP

Table 2, compose a summary of the three companies' answers regarding follow-up. More detailed information is found in the following texts in this section.

Table 2: Table covering questions asked about follow-up

Follow-up			
Company: / **Question:**	**Scania**	**IAC**	**Saab**
Follow-up, regarding if standardized work instructions is used, is performed according to:	Team leaders 1/shift/team area Production leader 1/day/line Factory manager 1/day/factory Production manager 1/month/factory	Team leaders 1/shift/team area Work leaders 2-3/week/line	Team leaders 1-2/week/team area Production leader 2/week/line
Counteractions, if standardized work instructions are not used, is performed according to:	Communicate importance of standardized work instructions Possible update of standardized work instructions	Communicate importance of standardized work instructions Possible update of standardized work instructions If deviation continues to occur the assembler will be removed	Action is analyzed Action plan is created to avoid repetition of deviation Possible update of standardized work instructions
In charge of writing/developing standardized work instructions are:	Assemblers	Technician department	Assemblers together with team leaders
Who pass/sign the standardized work instructions?	Assemblers and production leader pass position standard document Assemblers and production process engineer pass tempo description	Technician department	Pre-production engineer Team leader Production leader

4.2.1 SCANIA

At Scania, the team leaders perform position follow-up once per shift at every assembly area. The production leader perform position follow-up once a day at their area. The factory manager perform follow-up once a day in the factory and the production manager once per month in the factory.

The follow-up includes an investigation regarding if assembly workers performs their work in an ergonomic manner and if they follow the standardized work instructions.

When performing the follow-up, it is essential to communicate the importance and the positive result that standardized work instructions contribute with. The person who performs the follow-up should also make sure that the assembly worker feels accessorial and listen to his or hers improvement suggestions. Questions are asked to make sure that the assembly worker understands why he or she assembles in this manner. If the assembly worker does not work according to the position standard, it is important to investigate if his or hers way of performing the task is better. If this is the case it is documented and evaluated and used in the work instruction. If this is not the case, they make sure that they communicate the importance of following the work instructions.

Assembly workers write the position standards and the tempo description. The assembly worker and production leader approves of the position standard, both shifts shall agree with the new standard. If there are two suggestions on a change of the position standard or tempo description and the two shifts are not in agreement of which one is best it is the production leader that decides which alternative to use. The tempo description should be approved by the production process engineer and the assembly worker to make sure that they are written according to standardized documents. The person who is responsible for the position is considered an expert on the position and is in charge of updating the position standard.

The position standard and the tempo description are always of high quality and they always include the necessary information due to that the assembly workers write them since they are the experts on their work.

4.2.2 IAC

The technician department at IAC develops new work instructions and the production leader performs updates on existing work instructions. To make sure that the standardized work instructions are followed; all team leaders perform a follow-up of one work station and its connected work instruction, each shift. The work leaders also perform a similar follow-up several times a week. The follow-up is a part of the "Four steps for improvement" plan, a lean implementation at IAC. If an assembler does not follow the work instruction, an investigation is launched regarding if the assembly workers way of perform the work task is more efficient, and if so they will implement this work procedure into the work instruction. This process should take 24 hours. If the assembly workers way of performing the work task is not the best way, they try to educate the assembler of the origin and meaning of the work instructions. This is to get him or her to work according to the standards. If the assembler continues to not follow the work instructions they will be removed from that work station. To secure that assemblers have an ergonomic work environment, safety rounds are performed once each month at every line. Another important step towards a good ergonomic environment is that an ergonomist perform an evaluation twice a year in some part of the production facility.

4.2.3 SAAB

The team leaders and assemblers, at Saab, perform follow-up to ensure that standardized work instructions are followed by the assemblers. This is done once or twice per week at each assembly area. During these follow-ups, ergonomic factors are also investigated. Production leaders perform the same kind of follow-up at least twice a week. The follow-up is performed according to a standard procedure named layered audit. If someone notice that the standardized work instructions are not being followed an action plan is written to prevent that the deviation occurs again.

The person who performed the deviation has to explain his or hers way of working and explain why this procedure is better than the standard. If it is better, the standard will be updated and if it is not better, the person has to start following the standards. When deviations occur the production leaders have to present counter measures to prevent the deviations from occurring again.

Assemblers and the team leader create and develop the standardized operation sheet and job element sheet. All these documents should be approved by the production leader to maintain high quality.

4.3 VISUALIZE STANDARDIZED WORK INSTRUCTIONS

Table 3 compose a summary of the three companies answers regarding visualize standardized work instructions. More detailed information is found in the following texts in this section.

Table 3: Table covering questions asked about visualization

Visualize standardized work			
Company: / **Question:**	**Scania**	**IAC**	**Saab**
How is sequence of assembly visualized?	Position standard document = A3 sheet Tempo description document = binder system	Standardized work instruction document = A3 sheet "Smartbox" = helping aid screen	Standardized operation sheet = A3 sheet Job element sheet = binder system
How is ergonomics visualized?	Position standard document =A3 sheet	Standardized work instruction document =A3 sheet	SARA
Where is sequence of assembly visualized?	Position standard at the position and tempo description at the work station	Work station	Standardized operation sheet at the position and job element sheet at the work station
Where is ergonomics visualized?	Position standard document, at the position	Standardized work instruction document, at the work station	SARA, at the work station

4.3.1 SCANIA

At Scania position standards visualize the sequence of assembly in an A3 sheet in front of the assembler; head high, at the position. Another document that is used is the tempo description; it provides the assembler with more detailed information regarding the assembling. This document is available in a binder next to the station. To minimize injuries at the work station both the position standard and the tempo description should visualize the auxiliary equipment that could be used in order for the work to become more ergonomic.

4.3.2 IAC

At IAC work instructions stepwise visualize the sequence of assembly. They contain the information of the assembly sequence. At the assembly line there is also auxiliary equipment called “smartbox”. This is a screen showing information on what to assemble and the sequence of assembling. The screen starts flashing in red when an error occurs. The work instructions are visualized in an A3 sheet in front of the assembler; at head high, at the work station. The “smartbox” is located at the work station in front of the assembler.

Furthermore, the visualization of ergonomics is close to nonexistent. In the work instructions, ergonomic risk factors, like safety hazards, are mentioned. A red cross in the work instructions with a matching informative text visualizes this. When they do Avix-analysis see appendix A - Avix, for their re-balancing they try to consider ergonomics and they prioritize good ergonomics. The reason for the low visualization of ergonomics is that the company stresses that it is more important to provide the assembly workers with education regarding ergonomics rather than to visualize it.

4.3.4 SAAB

At Saab, the sequence of assembly is visualized in two documents that are named standardized operation sheet, SOS, and job element sheet, JES. The standardized operation sheet is based on the job element sheet and the job element sheet includes more detailed information of how to perform the assembly. These two documents are required from leading roles in Saab and therefore they have to exist in the production lines. The standardized operation sheet is visualized on an A3 document at the station and the job element sheet is visualized in a document that is located in a binder next to the station.

The ergonomics and sequence of movement is visualized in a written document called SARA and it is located next to the standardized operation sheet at the work station. Here the work tasks at the work station, based on an investigation according to Saab's ergonomic evaluation, is rated according to the colors red, bad ergonomic, yellow, okay ergonomic and green, good ergonomic. This information is updated at every re-balance or once per year.

4.4 INVOLVE OPERATORS

Table 4 composes a summary of the three companies' answers regarding involving operators. More detailed information is found in the following texts in this section.

Table 4: Table covering questions asked about involving operators

Involve operators			
Company: / **Question:**	**Scania**	**IAC**	**Saab**
How do you motivate assemblers to work according to standardized work instructions?	Involve assemblers in work of improvements Assemblers develops standardized work instructions Reward system	Involve assemblers in work of improvement Educate assemblers in benefits of using standardized work instructions	Involve assemblers in work of improvement Assemblers develops standardized work instructions Responsibility areas Reward system
In what range do the assemblers have the opportunity to influence the standardized work instructions?	Assemblers develops standardized work instructions	Assemblers can influence the standardized work instructions during re-balance	Assemblers develops standardized work instructions

4.4.1 SCANIA

To motivate the assembly workers to work according to the position standard and the tempo descriptions the assemblers at Scania are highly involved in the improvement work of standardized work instructions. The fact that they create their own position standard and tempo description is considered a success factor when it comes to motivating the assembly workers. If assembly workers have contributed with improvement suggestions, that increases the productivity or quality and also when they discover deviation, they are rewarded.

Every morning assembly workers receive feedback on the performance from the day before, from both shifts. They also have improvement meeting every week where cause and effect from deviations are discussed. This provides the assembly workers with an opportunity to communicate their improvement ideas.

4.4.2 IAC

When it comes to motivation of assembly workers at IAC, the company tries to educate them to highlight the benefits of using standardized work instructions. Assembly workers are also a big part of the development of the standardized work instructions during re-balancing. By sharing their opinions about the quality of the work instructions or if the assembler want to change them, the assembler can present ideas to the team leader, who in turn can change the work instruction. If the assembler wants to change the information provided from the "smartbox", the same procedure takes place with the difference that the change has to be made by both the team leader and the technician. The company also uses carrot and stick to motivate their employees. When the assembly workers reach a goal or do well in the production they usually get a cake or some kind of food as an incentive. Another important factor that contributes with higher motivation is to involve the team leader in order for them to understand how and why different rolls act the way they do within the assembly line.

Furthermore, to involve the assembly workers they have separated the overall plant goal and the overall company goal with the aim to communicate them to the assemblers. These goals are showed once a week at a startup meeting. The company also visualizes each day's results for both shifts, which is summarized on an A3 sheet. The start-up meeting that occurs when each shift begin their work, provides them with the opportunity to discuss the result and problems from the day before.

4.4.3 SAAB

Saab tries to motivate the assemblers to work with standardized work instructions by making them active in the improvement work at the work stations. They write standardized operation sheet and job element sheet, provide improvement suggestions, and perform maintenance on tools and machines. They let the assemblers have different responsibility areas at the work stations and they perform follow-up on each other to make sure that standards are followed. They also uses a reward system which reward teams that perform very well and assemblers that provide Saab with improvement suggestions that increases productivity and quality.

4.5 AUTOLIV SWEDEN AB IN COMPARISON TO SCANIA, SAAB AND IAC

The main reason for performing a contrast study at Scania, Saab and IAC was the fact that all three companies have emphasized the importance of implementing standardized work instructions. Scania, Saab and IAC have a different manufacturing process than Autoliv Sweden AB. The amount of work procedures in each work position is more than Autoliv Sweden AB has at each station, which contributes with a longer cycle time. This is an important aspect to consider, but in this master´s thesis the weight lies on how strongly the companies, that the contrast study was conducted at, have emphasized standardized work instructions.

5 CONCEPTS AND EVALUATION

This chapter includes the developed concepts and their matching objectives. The chapter also includes an evaluation of the concepts where they are judged according to each other's qualities. For reading about the finalized recommendations you are referred to chapter 6 Recommendations. In the evaluation the most important aspect to consider from Autoliv Sweden AB's viewpoint is the cost of extra support time, meaning the time spent to implement and sustain the recommendations by the production process engineer and other supporting functions. Another important aspect to consider is the extra time spent on the concepts by operators, excluding assembly time.

5.1 IDENTICAL INFORMATION DURING TRAINING

Dreyfus and Dreyfus (1986) write about a five-step model that demonstrates the amount of knowledge personnel has in relation to the knowledge required to manage work tasks. Due to that Autoliv Sweden AB has a mixed group of operators where some are novice and some are experts, the amount of required time and resources during training will vary. However, an important aspect for Autoliv Sweden AB to remember is that every operator needs to be trained according to standardized work instructions and they need motorical practice to gain this knowledge. According to Fitts and Posner (1967) the autonomous phase, the final phase in the motorical readiness curve, is reached when operators has gained knowledge enough to perform motorical work tasks.

According to de Carvalho and Ferraria (2006), it is important that tacit knowledge is shared between individuals so that the spiraling knowledge creation in firms is expanded. This is done through socialization, which means that tacit knowledge is shared when two individuals discuss their experience with each other. Due to this it is essential, according to Dreyfus and Dreyfus (1986), for operators that are both novice and experienced to have the possibility to ask questions during practical training with their mentor. Another type of knowledge transfer that is important is called externalization. It is according to Dreyfus and Dreyfus (1986) when explicit knowledge is shared to operators through standards such as standardized work instructions. Carvalho and Ferraria (2006) also stresses that explicit knowledge could be converted into tacit knowledge through internalization. For this to be possible, operators has to practice the and understand explicit information to make the knowledge their own. The time an operator requires to understanding this information will vary due to that their experience level from similar work tasks will be at different levels.

Following are concepts for the recommendations on how to ensure that operators receive identical information when they are trained with new work task procedures according to standardized work instructions; see Figure 8.

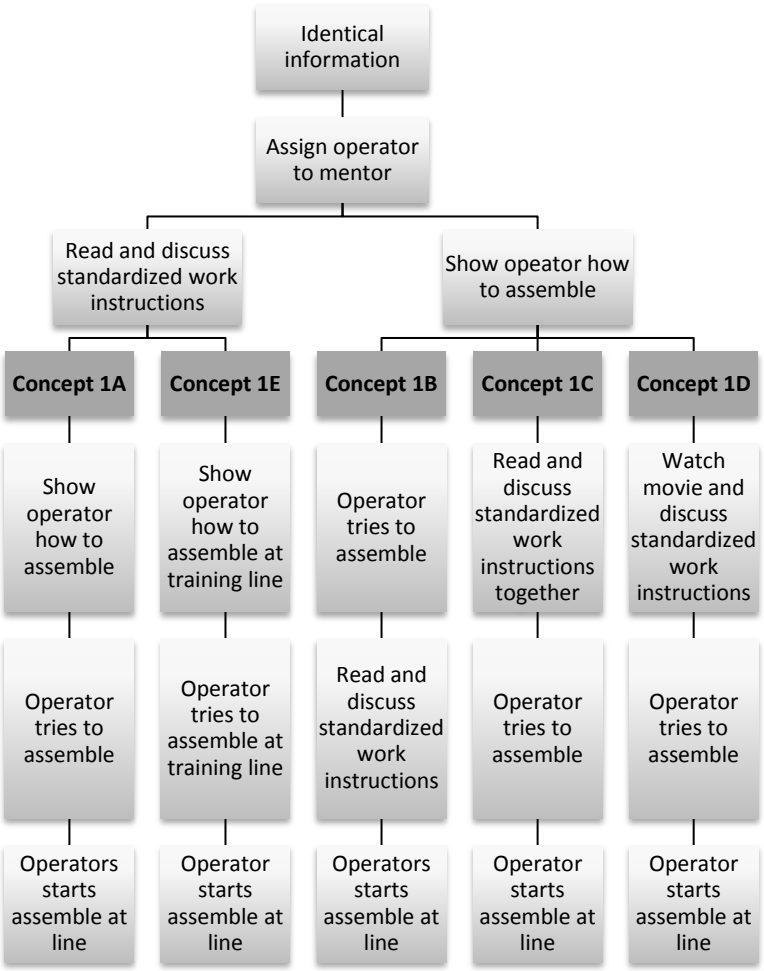

Figure 8: Process tree displaying the five concepts on how to ensure identical information during training

Since Autoliv Sweden AB recently has started using a mentor to train operators it is relevant to use this role as a mean to ensure that identical information is given to operators while they train new work task procedures. In the following concept the operator who will be taught the work procedure is therefore assigned to a mentor, whom should be an expert. To make sure that the operators receive identical information it is important that the mentor systematically follows the standardized work instruction when teaching the operator. This work method is successfully used by Scania and Saab, see chapter 4.1 Identical information. This method will only work if the standardized work instructions are updated, meaning that they represents the best possible work method there are in that current state.

It is important that the mentor who is teaching always has the latest information regarding standardized work instructions, to avert incorrect knowledge transfer. The mentors should undergo education that is standardized to make sure that they gain the same information and that they know how to teach the same work methods and techniques. This is showed to be successful according to Saab, see chapter 4.1 Identical information. The mentor has the responsibility to ensure that operators reaches previously set goals regarding standardized work instructions, ergonomics and the importance of standards and the education of mentors should ensure that they are knowledgeable within these three areas.

Granberg (2004) claims that the learning process can be decreased or even blocked if individuals are forced to perform work tasks, therefore it is important that the mentor responsibility should be assumed voluntarily by the operator holding it. The mentorship should be a role that several individuals have within the team to ensure that there always are mentors available if an individual needs to learn new work task procedures.

The mentor should support the operator until he or she feels confident enough to work according to the standardized work instructions. The mentor should also make sure that the operator receives training on one work station at a time, which means that he or she is not allowed to work on a new work station until confident enough.

Kuhlmann, Piel and Wolf's (2005) study on memory retrieval reveal that stress damages memory retrieval for human individuals. Schwabe and Wolf (2009) on the other hand claim that the negative influence of stress on memory retrieval can be avoided if the context where learning takes place is the same as where the knowledge is tested. This indicates that the operators should, in an as large extent as possible, be taught about the standardized work instructions in the same context as they are going to perform the work tasks.

The most appropriate approach for training would therefore be to teach the operators about standardized work instructions at the work station, but this will not be an optimal solution for Autoliv Sweden AB. This is due to the narrow spaces around the work stations. If the operator and the mentor stand by the work station when discussing the standardized work instruction it will result in both an enhanced level of stress for the operator who work at the work station as well as for the operator who is taught the standardized work instructions. This is due to that they will interfere with the working operator's work task procedures. The discussion about the standardized work instructions will therefore be performed in a room separate from the work station in concept 1A, 1B, 1C and 1D.

5.1.1 CONCEPT 1A

The mentor and the operator start with reading through the standardized work instructions and discuss it in a room separate from the assembly area. Here the operator should be urged by the mentor to ask questions.

The next step is for the mentor to show how the assembling is done at the work station. In this stage it is also important to urge the operator to ask questions. Next step is to let the operator try assembling. The operator should get time enough to do this without any questions being asked from the mentor, to prevent divided attention, which according to Osvalder and Ulfvengren (2009) decreases learning efficiency. When the operator starts feeling confident the mentor once again take over the assembling to ensure that the operator gets a last chance to ask questions. Here the mentor should make sure that the operator understands how and why he or she performs different work tasks. The operator should not be allowed to learn a new work station until this knowledge is gained.

5.1.2 CONCEPT 1B

The mentor starts with showing the operator how the assembling is done at a work station, according to standardized work instructions. In this stage the operator is urged to ask questions.

The next step is to let the operator try assembling. Make sure that the operator gets time enough to try the assembling without any questions being asked from the mentor. When the operator starts feeling confident the mentor once again take over the assembling to ensure that the operator gets the chance to ask questions without having to concentrate on assembling.

The last step is for the mentor and the operator to read through the standardized work instructions and discuss it in a room separate from the assembly area. Here the operator should be urged by the mentor to ask questions on subjects that the operator does not understand. The mentor should make sure that the operator understands how and why he or she performs the different tasks in the work station by asking questions and filling in the knowledge gaps. The operator should not be allowed to learn a new station until the mentor is confident that the operator has gained the knowledge that is needed.

5.1.3 CONCEPT 1C

The mentor starts with showing the operator how the assembling is done at a work station, according to standardized work instructions. In this stage the operator is urged to ask questions about the assembly task.

After this is done, the mentor and the operator read through the standardized work instructions and discuss it in a room separate from the assembly area. Here the operator should be urged by the mentor to ask questions and the mentor should make sure that the operator understands how and why he or she performs the different tasks in the work station by asking questions and filling in the knowledge gaps.

The last step is to let the operator try assembling. Make sure that the operator gets time enough to do this without any questions being asked from the mentor. When the operator feels confident the mentor once again take over the assembling to ensure that the operator gets the chance to ask questions. The operator should not be allowed to learn a new station until this knowledge is gained.

5.1.4 CONCEPT 1D

The mentor starts with showing how the assembling is done at a work station, according to standardized work instructions. In this stage the operator is urged to ask questions.

The next step is to let the operator watch a movie on how to perform the assembling at the work station. The movie is made by a production process engineer together with an operator who, in the movie, performs the work task in a correct procedure according to the standardized work instructions. The movie should be displayed in a room separate from the work station. The operator is allowed to watch the movie an innumerable amount of times until he or she feels confident enough to discuss the animation and later on start assembling. It is crucial that the operator and the mentor discuss the work procedure and sort out possible questions that the operator has during the time that the operator watches the animation. Here the mentor should make sure that the operator understands how and why he or she performs the different tasks in the work station by asking questions and filling in the knowledge gaps.

The last step is for the operator to try to assemble at the work station. This should be done under supervision of the mentor. The operator should not be allowed to learn a new work station until correct knowledge is gained.

5.1.6 CONCEPT 1E

The mentor and the operator start with reading through the standardized work instructions and discuss it in a room separate from the assembly area. Here the operator is urged by the mentor to ask questions.

The next step is for the mentor to show how the assembling is done at a training line. In this stage it is also important to urge the operator to ask questions. The next step is to let the operator try assembling. Make sure that the operator gets time enough to do this without any questions being asked from the mentor. When the operator feels confident the mentor once again take over the assembling to ensure that the operator gets the chance to ask questions. Here the mentor should make sure that the operator understands how and why he or she performs different work tasks.

When the mentor considers the operator skilled enough, he or she is allowed to start working at the real work station at the assembly line.

5.1.7 EVALUATION OF CONCEPTS

In concept 1A, 1B, 1C and 1D discussion about standardized work instructions is done in a room separate from the assembly area. This reduces the amount of distractions, stress and other external factors when encoding memories from short term memory to long term memory, resulting in faster learning. These thoughts are in line with Osvalder and Ulfvengren (2009) beliefs about how stress negatively effects the encoding of memories from short term memory to long term memory. Höffler and Leutner (2007) claim that when learning with static or dynamic visualization, the capacity of the short-term memory is the limiting factor. This is another argument to keep the distractions and stress at a minimum during discussion about standardized work instructions.

The negative aspects of concept 1A is that it is difficult for the operator to gain an overall understanding of the work task since the standardized work instructions are discussed before the operator have seen the work station. This is a potential negative aspect resulting in impeded learning. Impeded learning can also occur when the operator is showed how to assemble at the work station, due to distractions and stress from the surroundings. These are once again thoughts that are in line with Osvalder and Ulfvengren's (2009) thoughts.

In concept 1B, the operators are presented to the correct context from the beginning since they stand by the work station from the start of the training. This gives an enhanced understanding of the work task and foster learning which is supported by Fitts and Posner (1967). The negative aspect of concept 1B is the increased level of stress the operator can experience due to that the mentor show the work task at the work station and then let the operator try to assemble immediately, without the chance to gain more knowledge from the standardized work instruction. Stress can, according to Osvalder and Ulfvengren (2009), be overwhelming for the short term memory and result in less effective learning.

In concept 1C the operators are in the correct context, they stand by the work station, from the beginning which results in an enhanced understanding on what and how to assemble, which is supported by Fitts and Posner (1967). Without this knowledge it becomes difficult to connect the knowledge gained, when later on discussing the standardized work instructions, to the work task and thereby risk losing the meaning of the standardized work instructions. According to Osvalder and Ulfvengren (2009) and Freivalds and Niebel (2009) the knowledge gathered in the long term memory is stored for a life time, but the hard part for individuals is to retrieve this knowledge. They also claim that the knowledge in the long term memory is more dependent on meaning than on information and it is therefore crucial to connect the information operators are presented with to something that has a meaning.

Downsides to concept 1C, that impedes learning, are the distractions occurring while the operator is showed how to assemble at the work station.

Concept 1D is supported by Höffler and Leutner (2007) meta-analysis, where they claim that learning with animations is more effective than learning with static pictures. Due to this rather extensive analysis this concept is considered important, even though there are studies with the opposite opinion as a result. Concept 1D ensures that the information gained by the operators is more identical than the rest of the concepts. This is because the mentors are not able to change the information taught to the operators due to that the information shared is static - it is displayed by a movie and the information will not change until the movie is changed.

Another valuable aspect in this concept is that operators can gain knowledge in the time that he or she requires by pausing the movie. It can also be repeated as many times as wanted by the operator. These are both aspects that improve the efficiency of learning. Other positive aspects with concept 1D is that the operators are set in the correct context, they stand by the work station, from the beginning which results in an enhanced understanding on what and how to assemble. The operators also have the chance to gain more knowledge of the work task in the process of discussing the standardized work instructions before they try to assemble. Concept 1D requires less time to be spared from other personnel in the work team, compare to the other concepts, due to that the mentor does not need to be present the entire time when the operator watches the movie. It is still important to underline the value of combining the use of videos together with a mentor. If the mentor can answer questions and discuss the video with the operator, the operators' learning will increase. These thoughts are in line with Gerjets and Scheiter's (2009) writing that learning is increased if help is provided to facilitate the gaining of information and understanding when learning through using videos.

Downsides with concept 1D are the many distractions, which impede learning, while the operator is showed the work task. Another downside is that there would be a lot of support time required by, for example, the production process engineer since the movie needs to be made as well as updated every time the standardized work instructions are updated.

Concept 1E ensures higher quality on the production lines, since the operator is allowed to make most mistakes regarding quality at the training line. These could have been mistakes that ended up, in a worst case scenario, as a customer claim. Another benefit with concept 1E is that it does not require much operator time since the time the mentor is needed is reduced. In accordance with Ortiz (2006) thoughts of training lines, this concept will result in that the productivity is kept high within the real assembly line and ensure that competence and skills of operators is high. The negative aspects with concept 1E are the very high implementation cost and that it requires a lot of support time. The support time would consist of the preproduction engineer's and the production process engineer's time spent on the obtaining and maintaining of the training line.

To evaluate concept 1A – 1E a Pugh matrix was used, see Table 5 below. For more detailed information of the Pugh matrix method see chapter 3.8.1 Evaluation table.

Table 5: Evaluation table

Criteria:	**Weight**	**Reference**	**Concept 1A**	**Concept 1B**	**Concept 1C**	**Concept 1D**	**Concept 1E**
Support time	*2		0	0	0	-1*2	-2*2
Operator time	*1		-2	-2	-2	-1	-2
Level of information	*1		+1	+1	+1	+2	+1
Effectiveness of learning	*1		+1	+1	+2	+3	+2
Sum:			0	0	+1	+2	-3

Most amount of support time is needed for concept 1E, due to that a whole line needs to be implemented. Concept 1D requires less support time than concept 1E but still more than the rest since the IWI system requires more support time from technicians than concept 1C, 1B and 1A does.

Concept 1D requires the least amount of operator time due to that the operator will be able to learn about the work procedure without utilizing the mentor.

Concept 1D is the concept that best keeps the information taught to operators static. It is therefore rewarded with a +2 in the evaluation table.

Concept 1D is also considered to be most effective for learning followed by concept 1C which is followed by the rest of the concepts. The reason for this is that concept 1D, which includes visualization with animations, is considered, by the authors, to help the operator more when it comes to learning from standardized work instructions compared to using static pictures and texts. One reason for this is that the operators can use the animations and learn in their own pace. Another reason why this concept is considered effective for learning by this master's thesis authors is that the operator is in the correct context from the beginning.

According to the evaluation table, see Table 5, concept 1D is the best concept to implement to reach an identical information flow to operators that are educated at a work station. It is also the concept most beneficial for supporting operators' learning.

Concept 1D requires that the movie is updated and changed whenever the standardized work instructions are changed. Autoliv Sweden AB does not have resources enough as it is today to ensure that their standardized work instructions are updated. Since it is crucial that the movie is changed when the standards are changed this is a predicament. Therefore concept 1D should be considered to be

implemented in the future when Autoliv Sweden AB is able to maintain the system in a correct manner.

According to the evaluation table, see Table 5, concept 1C is the second best concept to implement at Autoliv Sweden AB, next after concept 1D. Since concept 1D is not possible to implement in the current state concept 1C should be viewed as the concept to implement today. By implementing concept 1C Autoliv Sweden AB will reach an efficiency of learning as high as possible. This is because the setup of the training is developed to increase learning as much as possible by first letting the operator take part of the context in the work station, then read through and discuss the standardized work instructions and at last try assembling. This is in accordance to Fitts and Posner (1967) thoughts about learning, where a human needs to connect the information regarding the work procedure with the practical performance of it before reaching the autonomous phase in the motorical readiness curve. By performing the training in this way the distractions will be as low as possible and foster learning. Concept 1C combined with that mentors are used will result in the ability to teach operators with as identical information as possible.

5.2 FOLLOW-UP

This section includes concepts for the recommendations on how, by whom, and when to perform follow-up regarding if standardized work instructions are followed by the operators, see Figure 9. This section also includes the evaluation of the concepts and the reasoning for choosing the final concept to recommend.

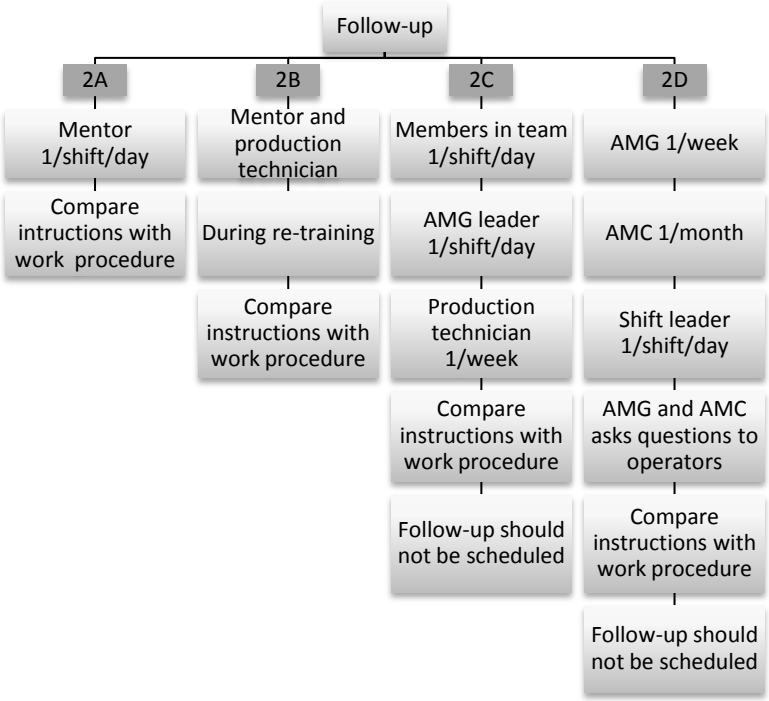

Figure 9: Process tree displaying the four concepts on how to perform follow-up

5.2.1 CONCEPT 2A

A mentor in each team should perform follow-up once per shift each day. The mentor should go through the standardized work instruction and step by step compare the instructions with what the operator does when he or she is working.

5.2.2 CONCEPT 2B

Follow-up should be performed by each team during re-training of employees, which occurs once per year. The person responsible for this event should be the mentor from each team together with the production process engineer. The mentor and the production process engineer should go through the standardized work instruction and step by step compare instruction with what the operator does when he or she is working. This could contribute with that everyone has a chance to learn from each other.

5.2.4 CONCEPT 2C

The team should perform self-monitoring once per shift each day and the AMG leader, see Appendix B- Organizational Structure at Autoliv Sweden AB, and production process engineer should perform follow-up once per week within the lines they are responsible for. The self-monitoring and the follow-up done by the AMG leader and the production process engineer should be carried out by reading through the standardized work instruction and step by step compare them to what the operator does when he or she is working. The follow-up should not be scheduled but be performed when the operators are unaware of it.

5.2.5 CONCEPT 2D

One individual from the AMC group, see Appendix B- Organizational Structure at Autoliv Sweden AB, should perform follow-up once per month and one individual from the AMG group should perform follow-up once per week within the lines they are responsible for. The shift leader should also perform follow-up once per shift, each day. During the follow-up by both AMC and AMG, questions regarding standardized work instructions should be asked to make sure that operators understand the importance of working according to them. They should also read through the standardized work instruction and step by step compare them to what the operator does when he or she is working. The exact time of follow-up should not be known among operators, this is to make sure that the standardized work instructions are followed at all times and not only when follow-up is performed.

5.2.6 EVALUATION OF CONCEPTS

Concept 2A has a positive aspect due to that follow-up is performed each day in all shifts, which demonstrates the importance of work according to standardized work instructions. This is in line with the thoughts of Ortiz (2006) and Sörqvist (2004) who claims that by performing follow-up regularly, standardized work instructions are ensured to be updated and the quality will be adequate.

The negative aspect is that it does not include many hierarchy levels within the company, which is important to establish the significance of follow-up to the operators. The importance of involving many hierarchy levels is stressed by Imai (1986) due to that all personnel should feel responsible to perform follow-up and also that it highlights the non acceptance of deviation from standardized work instructions. The positive aspect of not involving many hierarchy levels is that follow-up do not require much support time.

Concept 2B is positive in the aspect that operators have to share skills and knowledge with each other during the re-training. The negative aspect is that the follow-up is scheduled which could result in that standardized work instructions is only followed during follow-up. The importance of not scheduling the follow-up is shared by Scania see chapter 4.2 Follow-up. Another negative aspect is that it does not include many hierarchy levels within the company, which is important to establish the significance of follow-up to the operators. The importance of involving many hierarchy levels is in line with Imai (1986) thoughts. The positive aspect of not involving many hierarchy levels is that follow-up do not require much support time. A third negative aspect is that follow-up is not performed more than during re-training, which could result in a long time period between each occasion. To emphasize the importance of performing follow-up, the time interval between each occasion should be short, which is in accordance with Ortiz (2006) and Sörqvist (2004) thoughts.

Concept 2C's positive aspect is that it includes many hierarchy levels, due to that it emphasizes the significance of follow-up, which is in line with Imai (1986). Another positive aspect is that follow-up is not scheduled, which ensures that operators work according to standardized work instructions in a consistent manner and not only during follow-up. This has been shown to be successful at Scania see chapter 4.2 Follow-up. A negative aspect with this concept is that it could be difficult for the team to perform follow-up on each other. If operators only perform follow-up within the team, it is a risk that the

follow-up is forgotten. It could also be difficult for the team to perform the follow-up in an objective manner, which will result in that the standardized work instructions will not be used.

Concept 2D's positive aspect is that it includes many hierarchy levels, due to that it emphasizes the significance of follow-up, which is in line with Imai (1986). Another positive aspect is that follow-up is not scheduled, which ensures that operators work according to standardized work instructions in a consistent manner and not only during follow-up. This has been shown to be successful at Scania, see chapter 4.2 Follow-up. A third positive aspect is that the person who performs the follow-up should ask questions regarding standardized work instruction to create an understanding among the operators of why they perform the work task like they do, which is in accordance to Sörqvist (2004), Wall (2005), Scania, IAC and Saab, see chapter 4.2 Follow-up. Follow-up is performed each day, which emphasize the importance of standardized work instructions according to Ortiz (2006) and Sörqvist (2004).

Concept 2D is the best concept for Autoliv Sweden AB to adapt. This is because it includes most hierarchy levels within the company in the follow-up, which emphasize the importance of following standardized work instructions. To succeed with follow-up it has to be consistent and performed frequently, which concept 2D prescribes. Concept 2D requires a lot of support time, due to that many employees on different levels within the company will be a part of the performance of follow-up. Since follow-up is not established at Autoliv Sweden AB, this support time is necessary, to establish an acceptance and understanding regarding the benefits that following standardized work instructions bring and also that it is not acceptable to perform work tasks in another manner than according to standardized work instructions.

Concept 2C is excluded for further elaboration due to that the importance of follow-up is not communicated to the operators at this point in time at Autoliv Sweden AB. Self-monitoring requires that operators understand the importance of working according to standardized work instructions and also understand the importance of performing follow-up. When Autoliv Sweden AB has established this understanding among operators, it becomes possible to add self-monitoring in the follow-up.

The reason why concept 2A and 2B are excluded for further elaboration is due to that they do not include many hierarchy levels within the follow-up, which is very important for Autoliv Sweden AB at this point in time to establish. Concept 2B also indicates that the follow-up should be schedule, which is not optimal, the goal for Autoliv Sweden AB is to make sure that the standardized work instructions are used at all times and not only when follow-up is performed. Regarding the support time, concept 2A and 2B requires less support time but as stated earlier, this time is necessary for Autoliv Sweden AB to invest in, to emphasize the importance of standardized work instructions.

5.3 VISUALIZE STANDARDIZED WORK INSTRUCTIONS

To design a good system for visualizing information, it is relevant to know what influences individuals ability to make decisions and respond accordingly (Osvalder & Ulfvengren, 2009).

Fitts and Posner (1967) discusses that knowledge is gained during three phases where knowledge for the work task is deepened for each step. In the final phase, the autonomous phase, humans perform the work procedure in a routine based manner and do not have to reflect on how the work task is performed. According to Dreyfus and Dreyfus (1986) the human has, during the transition between the phases, gone from being novice or competent to becoming an expert.

Expert operators perform their everyday work tasks in an automated and routine based manner. These thoughts are in line with Ellström's (1996) arguing that in action level one, the routine based action level, individuals' actions require low attention and they are triggered by stimuli from the context. In an automated and routine based situation there is no need for the experienced operators to use visualization as an aid to trigger certain movements or actions in the assembly sequence.

Inexperienced operators perform their everyday work tasks in a slightly less automated manner and they sometimes need the aid of visualized instructions. This is in line with Ellström's (1996) thoughts about action level two, rule based action. In action level two the actions are taken on a more conscious level and for experienced operators they are based on rule of thumb. Experienced operators perform actions in level two when regular problem arise in the day to day work. Here they need an ability to identify and interpret the observations to trigger actions according to rule of thumb. Experienced operators know these rules from practice, but inexperienced operators do not. Therefore, it is important to visualize these rule of thumb for operators that are new at a work station.

When irregular problem arise, in the day to day work, experienced operators' actions are triggered from analyzed thinking, reflection and prior knowledge. These thoughts are in line with Ellström's (1996) thoughts about action level three, knowledge based action. He claims that actions in this level are needed in new and unknown situations or when problems that cannot be solved with standard methods arise in familiar situations. Therefore it will be difficult to use a visualization method to replace this knowledge among operators. Action level three requires great knowledge and competence from operators and this level should be a milestone to work towards for all operators in Autoliv Sweden AB.

Sometimes operators' actions are based on recurring reflections regarding a specific task in mind. These are according to Ellström (1996) actions in level four, reflection based actions. The operator reflects on if the tasks they carry out each day is performed in a correct way rather than if the correct tasks are being performed. This means that the actions are based on analyzing thoughts about the individuals' actions and the business' goals and policies (Ellström, 1996). By reaching action level four, Autoliv Sweden AB will be able to involve their operators in the work of developing standardized work instructions, see 5.4 Involve operators.

Operators in the assembly lines rely more on impressions perceived with their eyes than their ears. These thoughts are in line with Osvalder and Ulfvengren's (2009) claims that almost 80 % of all sensory impressions are detected via the eyes. The level of noise in the production lines can be almost overwhelming resulting in an situation where it is impossible to use auditory visualization. Therefore all of the following concepts will include visual displays and none will include auditory information.

5.3.1 CONCEPT 3A

Concept 3A should display the assembly sequence. It is similar to the SWI, see Appendix D – Standardized work instruction, used today at Autoliv Sweden AB. The difference is that it needs to include more details with thorough texts and pictures. It should be located close to the line and it should display what auxiliary equipment there is in the work station and how to use it. It should also display the most critical movements in an ergonomic view point, see Figure 10.

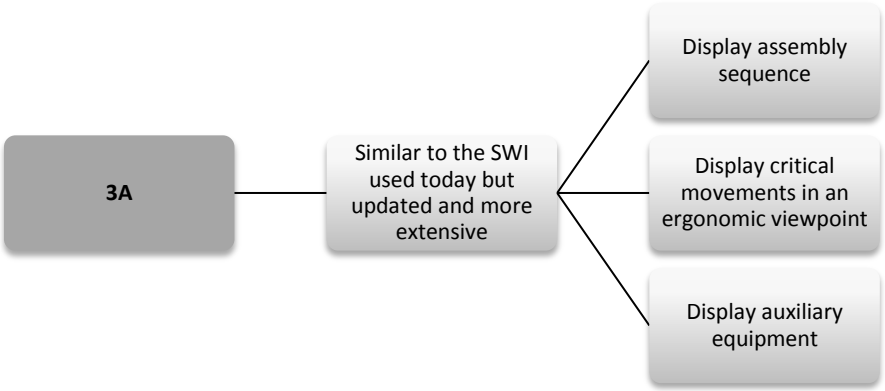

Figure 10: Process tree displaying concept 3A

5.3.2 CONCEPT 3B

Concept 3B, see Figure 11 for visualization of the concept, is a system where videos and animations are possible to use. The IWI system, see Appendix C - Interactive Work Instruction, with texts, pictures and movies could be used. It should be located at each work station. The sequence of assembly is showed, as the operator works, in the IWI. If the operator needs more detailed information, it is possible to find this through pushing a button on the screen. Touch screen is to prefer since it facilitates the work of finding the correct information. The IWI should be located next to the work station and it should display what auxiliary equipment there is, when to use it and how to use it. It should also display the most critical movements from an ergonomic view point.

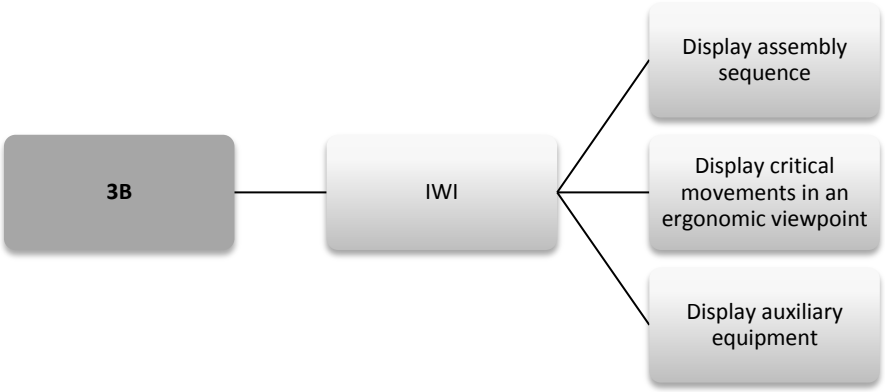

Figure 11: Process tree displaying concept 3B

5.3.3 CONCEPT 3C

Concept 3C is a system where an A3 sheet combined with a binder system is used, see Figure 12. An A3 sheet at the work station should be used to visualize the sequence of performing tasks at the assembly station. The A3 sheet visualizes how to perform the standardized work instructions in a perspicuous way which results in an easier system when performing follow-up. The auxiliary equipment should be displayed at the A3 sheet so that the information on how and where to use the equipment is easy to reach. The A3 sheet will not be extensive enough to show all important information that might be needed when there is a question regarding temporary problems at the work station. More elaborate information should be visualized in a binder, similar to the SWI used today at Autoliv Sweden AB. The difference between the more elaborate binder and the SWI used today is that the documents in the binder should be more thorough and extensive in the description of sequence of performing the task at the work station. The binder system should also display the most critical movements from an ergonomic view point and the auxiliary equipment. This document does not need to be located at the work station but still quite close to it, so the information is easy accessed.

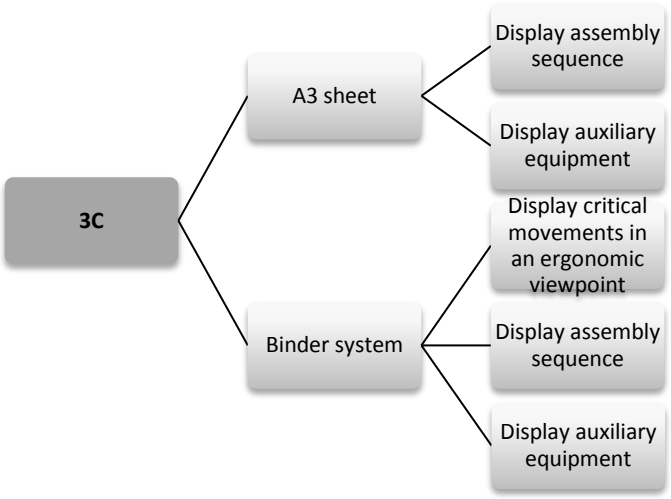

Figure 12: Process tree displaying concept 3C

5.3.5 EVALUATION OF CONCEPTS

According to Ellström's (1996) action levels, there is a need to visualize instructions for inexperienced operators during their day to day work and when regular problems arise. There is also a need to visualize the standardized work instructions for when follow-up is performed. There are many empirical studies carried out to investigate what means to use when visualizing information or instructions, to obtain the most effective learning. The outcome of the studies is an ambiguous matter according to Gerjets and Scheiter (2009) and it is therefore difficult to favor learning with dynamic information over learning with static information. Tversky, Morrison and Betrancourt (2001) write that the efficiency of learning with animated graphics is less than when learning from static graphics. Wouters, Paas and van Merriënbour (2010) says that the reason for the less effective learning when using animated graphics is due to an overload of the cognitive capacity of learners and thereby reduce the effectiveness of learning. Höffler and Leutner (2007) performed a meta-analysis which indicates the opposite; there is an overall advantage of learning with instructional animations over static pictures. These are all arguments that make it difficult for the authors to choose a mean to use when visualizing. The decisions for choosing the correct concept are therefore mostly based on other influencing facts, presented in the following texts.

Concept 3A is more cost efficient than the rest of the concepts since it will not require much time spent from operators nor support time from production process engineers or other roles in the higher hierarchy. A negative aspect with concept 3A is that it will not be as easy to perform follow-up at the work stations as it would be with concept 3B and concept 3C due to that it will not be easy to visually decide if the standardized work instructions are followed or not.

When follow-up takes place with this concept the individual performing it has to collect the SWI from where it is located and then walk back to the work station instead of being able to see the work procedure immediately. This is also a matter for the operator, who has to walk to the SWI to gain information. Osvalder and Ulfvengren (2009) claims that the amount of effort put into acquiring information is determinant for what information individuals attention is aimed towards. Therefore, a downside with this concept is that operators have to use much effort to require information and they will be less likely to focus their attention towards gaining the information that they might need. This could result in incorrectly performed work task procedures.

Concept 3B will decrease the time spent on handling papers and instructions connected to the standardized work instructions, since it will be displayed at a screen instead of papers. The concept enables that detailed information is easily accessed at the work station due to that it will be found in the IWI. When there are lines producing different modules, concept 3B is extra useful since it visualizes each product in a sufficient way. The concept enables that videos or animations are visualized at the work station. If the mental effort of performing a work task at the same time as handling instructions is reduced it will become easier for operators to carry out parallel work tasks. This is in line with Osvalder and Ulfvengren (2009) three factors which influence how easy or difficult it is to carry out parallel work tasks. This result in that inexperienced operators are able to work at a more complex work station than otherwise would be possible, due to that they with less mental effort can follow instructions from the screen at the same time as they assemble compared to if they have to use concept 3A or concept 3C. Concept 3B will also result in an easy way to perform a follow-up since the person who performs the follow-up does not need to know where the operator is in his or her assembly sequence since it will be displayed at the monitor.

Therefore, it will not require as much knowledge, about the assembly sequence, to perform the follow-up as it otherwise would. The downside with concept 3B is that the competence regarding IWI is quite low among workers at Autoliv Sweden AB. There are few people that really know the system and since it is complex, and an extensive knowledge of PLC programming as well as a high level of computer knowledge is required, it will be difficult for the operators to use it. The concerned operators would have to develop their knowledge regarding the system extensively. Also, the IWI system today is not fully developed and it will require many resources to reach the level where operators are able to take part in the development of the standardized instructions in the IWI.

Concept 3C will result in an easy way to perform a follow-up because the assembly sequence is displayed at the work station. The person who performs the follow-up will be able to follow the operator as he or she performs the work task by reading the information in the A3 sheet. It will also be possible for other personnel that, for the moment, does not perform follow-up to see and identify errors that are made by the operators. Concept 3C will be rather easy to implement in the work stations due to the similarity between the new folder system and the SWI system they are using today. Concept 3C is a successful visualization method according to the three companies included in the contrast study, see chapter 4.3 Visualize standardized work. To use an A3 sheet located at the work station combined with a binder system with more elaborate information was supported by both Scania and Saab in the contrast study, see chapter 4.3 Visualize standardized work.

The concept recommended for Autoliv Sweden AB is concept 3C. It is partly chosen because it is supported by the contrast study performed in the master's thesis; see chapter 4.3 Visualize standardized work. According to the standardization of work methods in Scania, IAC and Saab a functional way of visualizing is by using an A3 document at the work station together with a more detailed folder system in close connection to the work station. The difference between concept 3C and 3A are small, but the main reason for choosing concept 3C instead of 3A is the increased possibility to easily perform follow-up.

Concept 3B is a concept that should be viewed as a goal for the future due to the possibilities the system represent. It has the possibility to include movies and animations which should be used in the future as a mean to educate operators. This would result in less support time put into making the movies since it would be a combination of making standardized work instructions and movies for teaching operators. Concept 3B also has the possibility to reduce the support time and operator time spent on paper handling. It is important to emphasize that the system, as it is today, is not possible to implement. It needs to be easier to use by operators in the development and changing of the standardized work instructions.

5.4 INVOLVE OPERATORS

This section includes concepts for the recommendations on how to involve operators in the development of standardized work instructions, see Figure 13. This section also includes the evaluation of the concepts and the reasoning for choosing the final concept to recommend.

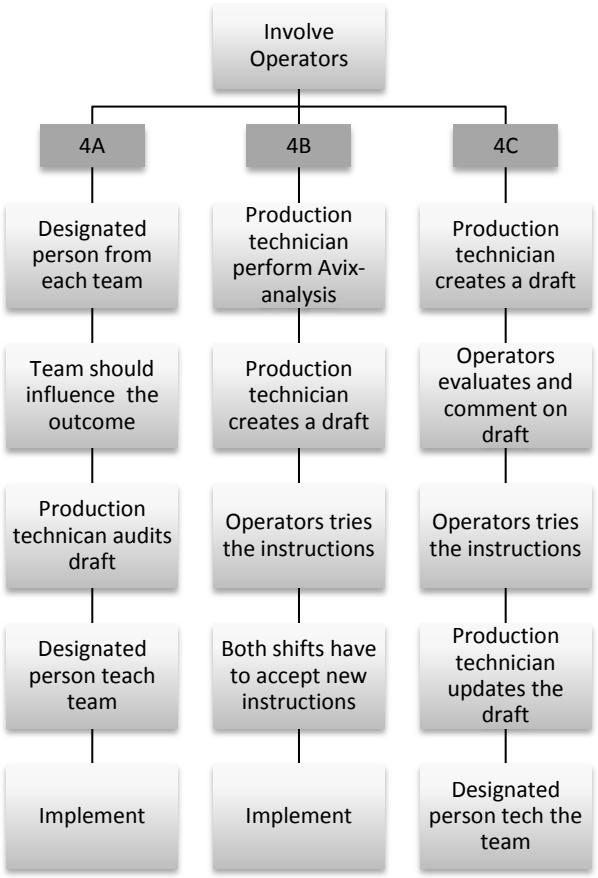

Figure 13: Process tree displaying how to involve operators

5.4.1 CONCEPT 4A

One designated person in each team is educated on how to write standardized work instructions. Everyone in the team is allowed to influence the outcome of the standardized work instructions by talking to the designated operator. This is done at meetings where improvement proposals from the team are cared for and adapted to the team's wishes through the designated person. This person is the one who creates a draft or updates the standardized work instructions. The production process engineer audits the draft of the standardized work instructions and updates it if necessary.

This procedure should be done within one week after the draft or change is created by the operator. The designated persons teach their team how to perform the new procedure and they try the instructions live, and then decides together with the production process engineer if it is good enough. All teams designated person have to accept the instruction before it could be approved by the production process engineer and a final implementation is done. If the designated persons do not agree it is up to the production process engineer to decide whether or not to implement it.

5.4.2 CONCEPT 4B

When there is a need for a standardized work instruction to change, the production process engineer together with operators from a team performs an Avix-analysis, to mutually develop the best possible standardized work instructions. The production process engineer writes a draft on new standardized work instructions or updates the old after discussions with the operators participating in the Avix-analysis. This is tested, the same week, by other individuals in the team who gained knowledge about the standardized work instructions through the team members participating in the analysis. This is to reach as high participation from the team as possible. The team is allowed to compare the new standardized work instructions with the old one to ensure that the change is toward the better. Both shifts have to accept the instruction before it could be approved and finally implemented by the production process engineer.

5.4.3 CONCEPT 4C

When there is a need for a standardized work instructions to change a production process engineer write a draft that the team later evaluates and comment. Within one week after the production process engineer has changed the standardized work instructions, designated operators in the team test them in reality. When there is a need for it, they give feedback on what to change to the production process engineer.

The production process engineer will then update the final version of the standardized work instructions and approve for it to be implemented in the work station. Designated operators in the team teach the rest of the team members the final version of the standardized work instructions.

5.4.4 EVALUATION OF CONCEPTS

The positive aspect of concept 4A is that it involves operators to a large extent, which is important to ensure that the standardized work instructions demonstrates the best way to perform work tasks. This is in accordance with Scania and Saab see chapter 4.4 Involve operators, and Ortiz (2006) thoughts. Another positive aspect is that by involving operators, their job satisfaction and motivation will increase, this thoughts are shared by Liker (2004), De Treville, Antonakis and Edelson (2005), Imai (1986) and Latham (2003). The negative aspect is that it requires operator time and support time during education of how to develop standardized work instructions, but when the designated person has received the education, it will only require operator time during the development of standardized work instructions.

Concept 4B has the positive aspect of high operator involvement in the development of standardized work instructions, which will increase job satisfaction and motivation and also ensure that the standardized work instructions demonstrates the best way to perform the work task. This is in accordance with Scania and Saab see chapter 4.4 Involve operators, Liker (2004), De Treville, Antonakis and Edelson (2005), Imai (1986), Latham (2003) and Ortiz (2006). The negative aspect of concept 4B is that an Avix analysis requires a lot of support time and also the right competence to perform a sufficient analysis. The work load on the production process engineer will increase due to that it is he or she that performs the Avix analysis.

Concept 4C's positive aspect is that it does not requires a lot of operator time, due to that it is the production process engineer that develops the standardized work instructions. The negative aspect is that it will increase the work load on the production process engineer. Another negative aspect is that it does not involve operators in a high extent which would result in that the acceptance of following standardized work instructions will be low among operators. To create acceptance of standardized work instructions operators needs to be involved in the development process according to Scania and Saab see chapter 4.4 Involve operators, Liker (2004), De Treville, Antonakis and Edelson (2005), Imai (1986), Latham (2003). It will also be difficult to secure that the standardized work instructions demonstrates the best way to perform the work task due to that the operators are not involved in the development process, which is important according to Scania and Saab see chapter 4.4 Involve operators and Ortiz (2006).

Concept 4A is most suitable for Autoliv Sweden AB to adapt. This is because it ensures that the standardized work instructions demonstrate the best way to perform the work task, due to the involvement of operators in the development work of standardized work instructions. This is in line with how Scania and Saab see chapter 4.4 Involve operators, is managing their standardized work instructions. High involvement of operators will create a deeper understanding of standardized work instructions and also contribute with that operators are more motivated to work according to the instructions, this thought is shared by Liker (2004), De Treville, Antonakis and Edelson (2005), Imai (1986) and Latham (2003). Due to that this understanding is not established at Autoliv Sweden AB at this point in time, this concept provides the possibility to increase the use of standardized work instructions. Another important aspect that makes concept 4A most suitable for Autoliv AB is the fact that the support time required when educating the designated person is only a onetime event which could be seen as an investment to make sure that operators become more motivated to work according to standardized work instructions.

The reason to have an operator that is educated regarding the development of standardized work instructions is to minimize the support time from production process engineer in this work and also to make sure that the quality of standardized work instructions are adequate.

The reason for that concept 4B is excluded from further elaboration and analysis is that it requires time to perform an Avix-analysis and it requires sufficient competence in order for it to be successful. To perform an Avix analysis every time standardized work instructions are updated or changed can be a waste of time, due to that some changes are small. It would lead to that the effort put in to the analysis is higher than the benefits it brings. Concept 4C is also excluded; this is due to the low level of operator involvement in development of standardized work instructions, which is important to ensure that the standardized work instruction demonstrates the best known way to perform the work tasks according to Scania and Saab see chapter 4.4 Involve operators. In both concept 4B and concept 4C the work load of the production process engineer will increase, which is negative due to that their other work tasks will be affected.

6 RECOMMENDATIONS

This chapter demonstrate the recommendations provided to Autoliv Sweden AB, which are based on the company's current state. Further reading about concepts is referred to chapter 5 *Concepts and evaluation.*

6.1 RECOMMENDATION 1 – CONCEPT 1C

This section includes the recommendations on how to ensure that operators receive identical information when they are trained with new work task procedures according to standardized work instructions.

Since Autoliv Sweden AB recently has started using a mentor to train operators it is relevant to use this role as a mean to ensure that identical information is given to operators while they train new work task procedures. To make sure that the operators receive identical information it is important that the mentor systematically follows the standardized work instruction when teaching the operator. This procedure will only work correctly if the standardized work instructions are updated, meaning that they represent the best possible work method at this current state, and the mentors master the updated version. It is important that the mentor who is teaching always has the latest information regarding standardized work instructions, to avert incorrect knowledge transfer.

The mentors should go through education that is standardized to make sure that they gain the same information and that they understand to teach the same work methods and techniques. The education of mentors should ensure that they are knowledgeable regarding; standardized work instructions, ergonomics and the importance of standards. The mentorship should be a role that several individuals have within the team to ensure that there always are mentors available if an individual needs to learn new work task procedures.

Granberg (2004) claims that the learning process can be decreased or even blocked if individuals are forced to perform work tasks, therefore it is important that the mentor responsibility should be assumed voluntarily by the operator holding it. The mentor should support the operator until he or she feels confident enough to work according to the standardized work instructions. The mentor should also make sure that the operator receives training on one work station at a time, which means that he or she is not allowed to work on a new work station until confident enough, this is supported by Fitts and Posner (1967) who argue that a human first receives and processes information and then uses this information in a motorical way to learn the work task correct. When the information has been understood and the motorical movements has been improved, the operator has reached the autonomous phase in the motorical readiness curve and can work unsupervised.

The operator who will learn new work task procedures is assigned to a mentor, whom is an expert and has reached the autonomous phase in the motorical readiness curve. The mentor should have the responsibility to make sure that the operator reaches previously set goals regarding standardized work instructions, ergonomics and the importance of standards. The importance of setting goals within training are in line with both Aamodt's (1999) and Latham's (2003) way of thinking that goals increase the motivation for a specific work task.

The mentor starts with showing the operator how the assembly is done according to standardized work instructions. The amount of time the mentor needs to spend on the operator depends on which knowledge level the operator holds. Dreyfus and Dreyfus (1986) argue that humans are divided into different stages depending on their knowledge for a work task. The time needed for the operator to acquire the highest stages will therefore vary. While the mentor shows how to assemble the operator is urged to ask questions about the assembly task.

This is in line with de Carvalho and Ferreira (2006) thoughts of that tacit knowledge is transferred from the mentor to the operator when questions are asked. These actions are called socialization. When there are no further questions from the operator they will together read through the standardized work instructions and discuss it in a room separate from the assembly area. This is also supported by de Carvalho and Ferreira (2006) who claim that explicit knowledge is provided to the operator throughout the entire discussion of standardized work instructions, the so-called internalization phase. Here the operator should be urged by the mentor to, once again, ask questions and the mentor should make sure that the operator understands how and why he or she performs different work tasks in the work station.

The next step is to let the operator try assembling, which is in line with Fitts and Posner (1967) thoughts of the importance to connect received information with practical experience during learning. This is to understand how and why to perform the work task and also to reach the autonomous phase in the motorical readiness curve. It is important that the operator gets time enough to assemble without any questions being asked from the mentor. When the operator starts feeling confident the mentor once again take over the assembling to ensure that the operator gets a last chance to ask questions.

By following these recommendations the operators are in the correct context, they stand by the work station, from the beginning which results in an enhanced understanding on what and how to assemble. Without this knowledge it becomes difficult to connect the gained knowledge, when later on discussing the standardized work instructions, to the work task and thereby risk losing the meaning of the standardized work instructions.

According to Freivalds and Niebel (2009) the knowledge gathered in the long term memory is stored for a life time and the difficult part for individuals is to retrieve this knowledge. Osvalder and Ulfvengren (2009) claim that knowledge in the long term memory, is more dependent on meaning than on information.

It is therefore crucial to connect the information operators are presented with, information from the standardized work instructions, to something that has a meaning, what they saw when they were showed how to assemble in the work station.

The operators have the opportunity to gain more knowledge of the work task in the process of discussing the standardized work instructions in a separate room without any distractions. This will reduce the amount of stress from the surroundings and according to Osvalder and Ulfvengren (2009) lead to a better encoding of memories from short term memory to long term memory and thereby increase the effectiveness of learning. This also means that the distractions and level of stress should be kept at a minimum the entire time the operator is learning about the standardized work instructions and ergonomics.

To urge the operators to ask questions and give them a possibility to question the methods used at the work station gives, according to Ellström (2009), the operators an approach to handle complex situations and problems that arise during work. Ellström (2009) suggests that this would not only imply that they are able to create and make suggestions on how to solve the problem, but also how to identify for what condition, work task and problem it concerns. As mentioned above, information is stored in the long-term memory for a lifetime. For the individual to easily make use of the stored information it is crucial that it has meaning. This is another indication for the importance of urging the operators to ask questions. Ellström (2009) writes that the limiting facts toward developing operators in this way are the organizational structure and lack of time for educating employees.

6.2 RECOMMENDATION 2 – CONCEPT 2E

This section includes the recommendations on how, by whom, and when to perform follow-up regarding if standardized work instructions are followed by the operators.

One individual from the AMC group should perform follow-up once per month and one individual from the AMG group should perform follow-up once per week within the lines they are responsible for. Other than that, the shift leader should perform follow-up once per shift, each day. During the follow-up by both AMC and AMG, questions regarding standardized work instructions should be asked to make sure that operators understand the importance of working according to them. They should also read through the standardized work instructions and step by step comparing them to what the operator does when he or she is working.

The occasion when follow-up is performed should not be known among operators, this is to make sure that the standardized work instructions are followed at all times and not only when follow-up is performed. To successfully perform an acceptable and respected follow-up it is important that good communication is established between the people who perform the follow-up and the operator, this idea is shared by Wall (2005), Tonnquist (2008), Scania, IAC and Saab see chapter 4.2 Follow-up.

Sörqvist (2004), Wall (2005) and Scania, IAC and Saab, see chapter 4.2 Follow-up, is in accordance of when operators do not work according to standardized work instructions, a discussion needs to be established to evaluate if their work method is better than the standard. This will result in that operators will create a higher job satisfaction due to that they are involved in the improvement work of standardized work instructions; this is supported by Freivalds and Niebel (2009), Ortiz (2006) and Productivity press development team (2002).

Autoliv Sweden AB has to make sure that the goal and purpose with the follow-up is shared with the operators and also that everyone within the company understand the benefits standardized work instructions contribute with, which is in line with thoughts of Freivalds and Niebel (2009) and Sörqvist (2004).

For the follow-up to be successful, documentation of the procedure needs to be established. The document should include information regarding who will perform the follow-up, when the follow-up should be performed and also which operator that the follow-up has been performed with. The document should also indicate if the operator pass or fail the follow-up. In the situation where the operators fails, measures needs to be taken immediately to demonstrate that it is not accepted to deviate from standardized work instructions. The most appropriate measure is to investigate if the standardized work instruction needs to be updated; this approach has been showed to be very successful according to Scania see chapter 4.2 Follow-up.

Imai (1986) shares the opinion of involving many hierarchy levels in improvement work such as follow-up. The reasons why this is highly recommended is that it ensures that every employee feels responsible to perform follow-up and also that it demonstrates that it is unacceptable to work in another manner than the standardized work instructions. This philosophy needs to be established among employees within Autoliv Sweden AB, in order for the follow-up to be successful. This will in long-term contribute with increased quality and productivity due to that follow-up ensures that standardized work instructions are followed, which is in accordance with Liker (2004). It will also ensure high quality of processes due to that standardized work instructions are evaluated during follow-up, which is supported by the thoughts of Bell, McBride and Wilson (2002).

The advantage that Autoliv Sweden AB will receive from performing follow-up regularly, which in this case means at least once per shift each day, is that it ensures that standardized work instructions are updated and that their quality remains adequate. This idea is shared by Ortiz (2006) and Sörqvist (2004). The reason for why follow-up should not be scheduled is proven to be effective in accordance with how Scania, IAC and Saab perform their follow-up see chapter 4.2 Follow-up. Autoliv Sweden AB has to ensure that standardized work instructions are not only in use during follow-up.

6.3 RECOMMENDATION 3 – CONCEPT 3C

This section includes the recommendations on what means to use to visualize standardized work regarding the assembly task sequence, as well as the appropriate working techniques from an ergonomic perspective.

An A3 sheet at the work station should be used to visualize the sequence of performing work tasks at the assembly station. The A3 sheet visualizes how to perform the standardized work instructions in a perspicuous way which results in an easier system when performing follow-up. The auxiliary equipment should also be displayed at the A3 sheet so that the information on how and where to use the equipment is easy to reach. The A3 sheet will not be extensive enough to show all important information that might be needed when there are questions regarding temporary problems at the work station for the operators. The more elaborate information should be visualized in a folder system, similar to the SWI used today at Autoliv Sweden AB. The difference between the more elaborate binder and the SWI used today is that the documents in the binder should be more thorough and extensive in the description of sequence of performing the task at the work station. The binder system should also display the most critical movements from an ergonomic view point and the auxiliary equipment. The binder system does not need to be located at the work station but still quite close to it, so the information is easy accessed.

The reason for why the information should be divided in an A3 sheet and a binder system is that operators have reached different levels in the motorical readiness curve. Fitts and Posner (1967) argue that humans need to connect provided information with practical training to reach the autonomous phase, which implies that non-experienced operators requires more support from standardized work instructions. This is also in accordance with Dreyfus and Dreyfus (1986) who discusses the five step knowledge model, where some are novice regarding the work task and requires more support from visualized standardized work instruction than other operators who are experts. Operators that have become experts perform work tasks in a routine based manner and have understood how and why the work task is performed.

These recommendations will result in an easy way to perform a follow-up. The person, who performs the follow-up, will, by reading the information in the A3 sheet, be able to observe and evaluate the operator as he or she performs the work task. The recommendations are supported by the contrast study performed in the master's thesis. According to the standardization of work methods in Scania, IAC and Saab a good way of visualizing is by using an A3 sheets at the work station together with a more detailed folder system in close connection to the work station, see chapter 4.3 Visualize standardized work.

Osvalder and Ulfvengren (2009) write that an individual's ability to detect stimuli from the surroundings and perceive it correctly is partly affected by expectations of what it looks like. This indicates that the information displayed in the visualization should be designed so it is similar to previously used visualization methods. This is one reason to keep a similar method to the one used today to visualize the standardized work instructions.

There are several empirical studies done in the field of visualization with static and dynamic information to find out which one that contributes most to the effectiveness of learning. The outcome of the studies is an ambiguous matter according to Gerjets and Scheiter (2009). Visualization with depictive information, e.g. the pictures used in the A3 document and the folder system, is supported by Watson et al. (2009). He means that the first time spent on assembly is faster when using depictive information than when using descriptive even though it is leveled the third time of assembly. The statement that efficiency of learning with static information is higher than the efficiency of learning with dynamic information is supported by Tversky, Morrison and Betrancourt (2001). They claim that a reason for this might be that animations are too complex and fast to be accurately perceived. Wouters, Paas & van Merriënbour (2010) write similarly that the cognitive capacity of learners can be overloaded when using dynamic information and thereby impede learning. Höffler and Leutner (2007) performed a meta-analysis which indicates the opposite; there is an overall advantage of learning with instructional animations over static pictures. This shows that both static and dynamic visualization could be viewed as the best method to use when visualizing. The authors believe that visualization through dynamic information should be viewed as a vision for the future for Autoliv Sweden AB since they today do not have the capacity and knowledge needed to fully use such a system. Therefore Autoliv Sweden AB should focus most of their resources on implementing the system with an A3 sheet and the new binder at the same time as they allocate some resources to the task of developing IWI further.

6.5 RECOMMENDATION 4 – CONCEPT 4A

This section includes the recommendations on how to involve operators in the development of standardized work instructions.

One designated person in each team is educated on how to write standardized work instructions. Everyone in the team is allowed to influence the outcome of the standardized work instructions by talking to the designated operator. This is done at meetings where improvement proposals from the team are taken care of and are adapted to the team's wishes through the designated person. This person is the one who creates a draft or updates the standardized work instructions. The production process engineer audits the draft of the standardized work instructions and updates it if necessary.

This procedure should be done within one week after the draft or change is created by the operator. The designated person teaches the team how to perform the new procedure and together they try the instructions live. Then they decide with the production process engineer if it is adequate. All teams designated person have to accept the instruction before it could be approved by the production process engineer and a final implementation is done. If the designated persons do not agree, it is up to the production process engineer to decide whether or not to implement it.

The main advantage that Autoliv Sweden AB will receive by involving operators in the development of standardized work instructions are that the operators will understand the benefits that they bring and also become more motivated to work according to them. This suggestion is in line with thoughts from Liker (2004), De Treville, Antonakis and Edelson (2005), Imai (1986) and Ohno (1978). Carroll (2002) also supports the thought of involving operators in the development of standardized work instructions.

In accordance with Latham (2003), job satisfaction and acceptance of work tasks will increase when operators receive responsibility at work, such as writing standardized work instructions, which will result in that they feel important to Autoliv Sweden AB and also that they are able to affect their working condition.

The reason why operators should develop standardized work instructions are based on how Scania and Saab are developing standardized work instructions, see chapter 4.4 Involve operators. This concept has proven to be successful to ensure that instructions are representing the best way of performing the work task and to ensure highly motivated operators that understand the importance of working according to standardized work instructions. With the support from the production process engineer, who will review the instructions before it is implemented, both high quality and best practice is ensured.

Another success factor in line with Tonnquist's (2008) thoughts is that employees have the ability to become more motivated toward work tasks when they are cooperating with each other and when a respected communication is established between them. The designated person from each team will be responsible for encouraging every member in the team to generate improvement ideas and also to ensure that everyone is a part of the development of standardized work instructions, which is supported by Tonnquist (2008). In accordance with Productivity press development team (2002) and Wall (2005) Autoliv Sweden AB has to ensure that the positive results and benefits with standardized work instructions are communicated to the operators. Autoliv Sweden AB has to carry out this information in a positive manner and emphasize that it is important for the company to establish a positive attitude among operators. If this is done, operators will accept standardized work instructions in a higher range and result in that they will be more creative and satisfied with their work.

7 DISCUSSION

In the following chapter the recommendations and the method are discussed and the authors' thoughts are phrased.

7.1 IDENTICAL INFORMATION DURING TRAINING

The authors believe that it is important that not only operators who get the chance to work with new work task procedures learn about standardized work instructions and ergonomics. Operators who are experienced with working at a work station also need to improve their knowledge of the work procedure since their work methods might be old and obsolete. By educating operators to become mentors, some of the experienced operators will be taught, but not all. Therefore, there need to exist a strategy for how to educate the remaining operators. This strategy is not included in this master's thesis scope and is therefore not discussed further, but the authors still stress the importance of developing this strategy for Autoliv Sweden AB.

A discussion should be held regarding the fact that approximately ten percent of the employees at Autoliv Sweden AB are temporary hired from staffing companies. This results in many operators working temporarily in the production lines and the turnover of employees is therefore an important aspect to consider when discussing training. The authors think that there is a need to separate the structure of education for temporary hired operators from operators that are permanently employed. Education for permanently employed operators should be more thorough and widespread compared to the education of the temporary hired operators, but it is crucial to remember that the temporary hired operators also are in need of education regarding standardized work instructions and the importance to follow it. It is a balance between keeping the education extensive enough at the same time as ensuring that the temporary hired employees quickly can start working at a work station. One cannot emphasize enough the importance of following a routine when it comes to this type of education to ensure that the time spent is kept

at a minimum at the same time as ensuring a high standard of the education.

The fact that the mentor should support the operator until he or she feels confident enough to work according to standardized work instructions might sound obvious but this is a given statement that could be difficult to achieve. Many times when operators start learning new work task procedures it is because the team is short of personnel and sometimes temporary employees from staffing companies are leased. The combination of a shortage of personnel and personnel that needs to learn new work task procedures with the use of a mentor, results in even less personnel to utilize. The need to maintain a high delivery precision requires a correct amount of operators that work in the production lines and therefore an easy solution is to leave the operator adrift, resulting in an operator who does not understand why the work task is performed and in what way it should be performed.

The focus on labor minutes per unit, LMPU, in the production lines also make this situation into a predicament that needs a solution like the recommendations made in this master's thesis. The recommendations will in the short run negatively affect the LMPU due to that the mentor will not directly contribute with producing products. In the long run the effect on the LMPU will be positive due to the reduction of unnecessary time spent on scrap and fixing errors that occurs because the operators' low knowledge about the products and how to assemble them. With this recommendation the operators, who learn new work task procedures, will gain more knowledge on how to perform the work task in the best way and therefore perform it in a sufficient manner without wasting unnecessary time in each work cycle.

7.3 FOLLOW-UP

Due to that Autoliv Sweden AB has a limited follow-up in the current state, the authors believe that it is important to, in a consistent manner, demonstrate to operators that follow-up will be an important part of the future. Therefore, it is significant to involve many hierarchy levels to emphasize the importance of performing follow-up and demonstrate that everyone in the company should be aware of that standardized work instructions are to be followed at all times. Another aspect why many hierarchy levels should be involved in the follow-up is due to that it would be performed in a more objective manner. It could be easier for personnel in higher hierarchy levels to question operators' work performance than it is for the shift leader to question it, due to that the shift leader is part of the team where personal relations could interfere.

For the follow-up to be accepted among operators, Autoliv Sweden AB has to communicate the importance of it and the benefits it will bring. If this acceptance is not reached among operators the follow-up could be seen as a punishment and a control activity performed by white collar workers and result in decreased motivation and job satisfaction. The relationship between white collar workers and operators must remain unstrained during follow-up to prevent this from happening. The communication and follow-up approach needs to be relaxed and not forced; otherwise it could result in rejected standardized work instructions by operators that refuse to work according to them. The author's claim that the acceptance of implementing follow-up as a daily activity will take time and they stress that personnel at Autoliv Sweden AB have to accept this.

Without follow-up there is a risk of decreased understanding of the instructions, which could result in that unnecessary mistakes are made. To avoid decreased understanding, all operators need to be educated; not just the ones that are taught by the mentors and have received information about the importance of standardized work instructions.

Another important factor concerning follow-up is that if the occasion when the follow-up should take place is unknown to operators, their knowledge about standardized work instructions are tested during the follow-up without the possibility for the operators to study in advance. Therefore it requires that operators are updated on standardized work instructions at all times and they have to be committed to them to pass the follow-up.

7.4 VISUALIZE STANDARDIZED WORK INSTRUCTIONS

The authors think that the A3 sheet could not just facilitate during follow-up, it could be beneficial for operators who are new at a work station as well. They could use the perspicuous A3 sheet as a reminder of what to assemble and what auxiliary equipment to use.

The folder system, that replace today's SWI, is needed to ensure that more detailed information, than what is presented at the A3 sheet, is available for the operators. If this system was excluded there would be major consequences for the operators since they would have to go through a more complex process when trying to find the information.

The authors also perceive the existing standardized work instructions as not adequate enough to fulfill the needs that will emerge with the given recommendations in this master's thesis. The question of what should and should not be displayed in the folder system is beyond the delimitations set for this master's thesis and will therefore not be discussed here, even though there is a need for this discussion at Autoliv Sweden AB.

The authors emphasize that it is important to remember when there is a need for visualization. One might fill the entire work station with wallpapers visualizing what to assemble and how to assemble it, without gaining any advantages from it. The importance is not to visualize information for the sake of visualization but to visualize in the correct context.

Situations where it is important to visualize work task procedures and ergonomic factors of work tasks in work stations are during follow-up, when training an operator with new work task procedures or when a work station is so complex that the benefits the operators receive from the visualization exceeds the time spent reading the instruction.

7.5 INVOLVE OPERATORS

A reason why a designated person from each team should be educated in developing standardized work instructions instead of educating the whole team is the non existing possibility of letting everybody in the team work with standardized work instructions. This is due to the increased labor minutes per unit, the fact that everybody in the team does not want to develop standardized work instructions and that shared responsibility equals no responsibility. It will also make it easier for the production process engineer to keep a good dialog during the development of standardized work instructions since it is one individual to discuss with instead of a whole team.

The fact that labor minutes per unit will increase during the development of standardized work instructions is negative. Autoliv Sweden AB has to decide whether to focus on involving operators and increase their motivation and acceptance level regarding standardized work instructions, or keep the amount of labor minutes per unit low.

This master's thesis is restricted to developing recommendations with one particular line in focus. The recommendation of using one person in each team that develop standardized work instructions might not be suitable for all the production teams at Autoliv Sweden AB since they vary in size and amount of standardized work instructions that they are in charge of. The authors believes that it is suitable to split the number of standardized work instructions, that larger teams are in charge of, so that several persons can be responsible for them. The required time to develop standardized work instructions and the required time to implement them should not be too long.

This is due to that operators will be more motivated to generate new improvement suggestions regarding standardized work instructions if they perceive that Autoliv Sweden AB implements their ideas.

Another concern to discuss is the question of whether or not there are enough operators who wants to take on the responsibility to develop the standardized work instructions. The authors believe that this position could be seen as a steppingstone for the operators to higher positions in the hierarchy, and therefore the need of worrying about this concern is low.

The authors strongly stress the importance of involving all personnel in the development of standardized work instructions. If operators have the opportunity to be a part of the development of the standardized work instructions their motivation towards their work will increase. Another important result that involvement of operators has is increased acceptance for follow-up. This is because the operators themselves have developed the instructions, which contributes to operators who are satisfied with their work method and work condition. If this feeling is established it could result in acceptance of follow-up in a greater extent.

7.6 METHOD DISCUSSION

To ensure that relevant information was included and that no information was missed during the work with this master's thesis, evaluation phases were used by the authors. The result from these evaluation phases indicates that the level of information was adequate and the method in this master's thesis was therefore successful to use.

The contrast study provided the authors with a deeper empirical foundation to the master's thesis that would have been problematic to gain in other circumstances. The outcome of the contrast study could have turned out differently if the interviews had been conducted in another manner.

If a qualitative research method had been used and precise research questions had been developed during the initial phase of the master's thesis work, a more specific outcome would have been elaborated instead of the relatively more general recommendations that now have been developed. If more companies had been visited during the contrast study, the number of generated concepts could have increased and they could have included more detailed information. This is because companies have different work methods regarding standardized work instructions, and this information could have resulted in a more widespread brainstorming during the concept generation with more detailed concepts. The companies chosen to perform the contrast study on are well known for their success regarding standardized work instructions, both in an industry and academic context. This has provided this master's thesis with a reliable knowledge foundation to generate concepts from.

This master's thesis is based on information with a specific assembly line in mind. If another assembly line would have been used, a different outcome of the recommendations could have been possible, e.g. the concept where IWI is used could have been recommended now instead of in the future.

Furthermore, the workshop that was held at Autoliv Sweden AB could have resulted in more information if it had been carried out during a longer time than 90 minutes or during more occasions. The outcome would also been different if the workshop had included more personnel from different hierarchy levels at Autoliv Sweden AB. During the workshop, the majority of the participants were production process engineers. If one more workshop had been held with the majority of operators, the result would differ and the generated concepts might not have concerned such a broad field of solutions. Another important factor that affected the result of this master's thesis is if Autoliv Sweden AB had used stricter criteria defining the evaluation of the developed concepts. This could have resulted in different recommendations compared to the once recommended today.

The benefit the workshop provided this master's thesis with was the internal reliability of the recommendations. This is due to that the authors could compare the developed concepts with personnel at Autoliv Sweden AB ideas'. By performing this workshop, the reliability of the developed concepts and recommendations increased.

7.7 FINAL THOUGHTS

Since the recommendations made have their foundations in work methods from three other companies, a literature study and the current state at Autoliv Sweden AB it seems likely that they are reasonable for Autoliv Sweden AB to adapt. It should also be possible for other companies in similar situations to use the recommendations in this master's thesis as an inspiration to improve their work with standardized work instructions.

The authors believe that Autoliv Sweden AB today stands at a cross-road where the different roads either lead to continuous firefighting where focus is on whatever came up on the latest revision concerning LMPU and overhead costs. Either it leads to a focus aimed away from LMPU toward a long term philosophy regarding continuous improvements of standardized work instructions, or it leads to a combination of the previously mentioned statements. The authors believe that the balance needs to be kept between the statements to, also in the future, be able to provide their customers with high quality products with zero defects. To achieve this, the focus needs to shift more towards working with the recommendations developed in this master's thesis.

The final and most important recommendation for Autoliv Sweden AB to contemplate is to begin with establishing an understanding among operators of what benefits standardized work instructions will bring and ensure that operators understand that it is not acceptable to perform work tasks in another way than according to standardized work instructions.

To enable this they have to improve their method when educating operators that are new at work stations as well as establishing a well-functioning system for follow-up. To increase the possibility of succeeding with education of operators and follow-up of standardized work instructions they should improve the visualization of standardized work instructions.

8 CONCLUSION

The developed recommendations in this master's thesis will provide Autoliv Sweden AB with means to ensure a possibility for leveled production output where operators perform work tasks according to standardized work instructions. The following chapter compiles this master's thesis conclusions.

To ensure that identical information is given to operators during training, a mentor should be used. By using the method of showing the work procedure at the work station and instructing the operator with the help of standardized work instructions as well as discussing it in a separate room from the assembly line; operators will learn the procedures in a correct manner. By following the standardized work instructions when teaching, all operators will learn how to perform the work procedure in the same way. To ensure that the mentor provides the operators with identical information, he or she needs to understand the importance of standardized work instructions, the benefits it will bring and be knowledgeable in how to teach it to operators.

Furthermore, to establish consistent follow-up and underline the importance of following standardized work instructions, many hierarchy levels need to be included in the work method. Follow-up should be performed each shift, every day by shift leaders to make sure that standardized work instructions are followed. However, personnel from higher hierarchy levels should also perform follow-up once per week and once per month. The occasions when the follow-up takes place should not be scheduled due to that Autoliv Sweden AB wants to make sure that standardized work instructions are used in a consistent manner at all times and not just when follow-up is performed. An important aspect of this recommendation is to establish adequate communication between the person who performs the follow-up and the operator. This communication should bring a deeper understanding for the operator about why standardized work instructions should be followed.

Visualization of standardized work instructions is an important aspect when training operators and during follow-up. By visualizing the sequence of how to perform the work tasks at the assembly station on an A3 sheet it will be easier for the individuals performing the follow-up. They will, with the help of the A3 sheet be able to see how the operator should perform his or her work task and easily detect if there is something wrong in the procedure. In the A3 sheet auxiliary equipment should also be visualized. This facilitates for operators that are new at a work station since it will act as a reminder on both what to assemble and what auxiliary equipment to use. The A3 sheet should be combined with a more extensive binder system. It should display information on the sequence of performing the task at the work station as well as the most critical movements from an ergonomic view point and where and what auxiliary equipment there is in the work station.

For Autoliv Sweden AB to involve operators in the development of standardized work instructions, a designated person from each team should receive education on how to develop instructions. Through this designated person, operators are able to influence and contribute with suggestions on how to perform work tasks. By involving operators in the development of standardized work instructions, Autoliv Sweden AB increases job satisfaction among operators due to that they are able to affect their work condition. When the designated person has developed the standardized work instructions with his or hers co-workers, a production process engineer audit the draft and if the standardized work instruction is approved it will be implemented.

The authors recommend further studies to be done regarding the most effective learning method, via animations or static pictures, in an assembly context. The authors also recommend studies regarding the efficiency of motorical learning from animations. Empirical studies regarding follow-up and its effect on production productivity and quality are also sought for.

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10 APPENDIX A – AVIX

Avix is a software program that companies use to perform method studies and work performance measurements. Together with video acquisitions, this tool provides companies with information to reach minimized waste within processes and reduce downtime (Solme, 2011). The information also makes it possible to continuously improve the process and to create work instructions. By performing Avix analysis companies gain knowledge about their processes and products that contribute with a possibility to improve problems and to encourage continuous improvement work within the company (Solme, 2011).

11 APPENDIX B- ORGANIZATIONAL STRUCTURE AT AUTOLIV SWEDEN AB

Autoliv Sweden AB's hierarchy structure is divided into AMO, AMC, AMG, and AMT. They have different responsibilities but they are heading in the same direction, which is to continuously improve the organization. The vision Autoliv Sweden AB has with this structure is to keep strong departments linked, focus on customer satisfaction, and develop a fast pace when it comes to information sharing, decisions and improvements (Autoliv Sweden AB, 2011).

11.1 AUTONOMOUS MANUFACTURING ORGANIZATION, AMO

The AMO group is responsible for creating goals and strategies as well as making sure that they are followed. The time horizon for activities within AMO is from one month to three years. AMO is also responsible for standardizing and simplifying for AMC and ensure that the AMC group has adequate level of competence (Autoliv Sweden AB, 2011).

11.2 AUTONOMOUS MANUFACTURING CENTRE, AMC

The AMC group is responsible for improvement of processes and systems. 80 % of these activities are planned within the time frame of 1 month to 1.5 year. They are also responsible for maintaining the adequate level of competence in the AMG group and to standardize and simplify for them (Autoliv Sweden AB, 2011).

11.4 AUTONOMOUS MANUFACTURING GROUP, AMG

The AMG group is responsible for planning and follow-up of activities. They should create discipline to standards and support the AMT group to achieve expected results. 80% of these activities are planned within a time frame of 1 month. They are also responsible for maintaining the adequate level of competence in the AMT group and to standardized and simplify for them (Autoliv Sweden AB, 2011).

11.5 AUTONOMOUS MANUFACTURING TEAM, AMT

The AMT is responsible for performing follow-up of results and making sure that they answer to organization goals. They should manufacture products in respect of quality, cost and delivery requirements. The AMT group should also follow standards and suggest improvements within the production (Autoliv Sweden AB, 2011).

12 APPENDIX C - INTERACTIVE WORK INSTRUCTION

Interactive work instruction is a computer based instruction system developed at Autoliv Sweden AB in Vårgårda to ensure the possibility to facilitate visualization of information for an assembly station connected to a machine. The system consists of two different softwares, Explorer and Creator, and as hardware it is possible to use a regular computer with a screen. Creator is the software used by the person who creates the instructions and Explorer is the interface between the operator and the instruction itself. The software uses PLC signals from the machines to keep track of the correct sequence. To design new instructions, Power Point is used and the slides are imported into Creator and sequenced according to the PLC signals. It is possible to insert buttons in the instruction slides for additional visualization for the operators. When there is an uncertainty about how or what to assemble operators could use these buttons to open new slides to visualize pictures, movies and texts. There is also a possibility to use touch buttons to further facilitate the work for the operators to get new instructions. The IWI system is still being developed so there is a possibility to influence features in the two programs. [1]

[1] Martin Östman, interview 2 pm 2/3 2011

13 APPENDIX D – STANDARDIZED WORK INSTRUCTION

Standardized work instructions, SWI, describe the best and safest way to perform a work task. This is to prevent accidents and ensure that the products maintain high quality and safe handling throughout the whole process. This system provides operators with means to ensure that problems are noticed early in the manufacturing process so that corrections can be made before the product is transferred to the next job site. SWI is also the foundation for Autoliv Sweden AB´s continuous improvement work (Autoliv Sweden AB, 2011).

14 APPENDIX E – WORKSHOP

The following chapter includes the two questions asked in the workshop performed at Autoliv Sweden AB. The method used is called silent brainstorming and the participant's generated ideas are showed in this chapter.

14.1 QUESTION 1

How should follow-up be performed to make sure that operators work according to standardized work instructions?

Idea 1

A Mentor at each line should perform follow-up regarding if operators work according to standardized work instructions. If operators do not follow the instruction, it is important that the mentor communicates with the operators to understand why he or she does not work according to standardized work instructions. The importance of good communication is due to that operators that do not follow standardized work instruction could have found a better method to perform the work task. A follow-up culture has to be established among the operators. They have to accept that they could learn from each other and also get proper education regarding ergonomic to find the best way of performing the work task and also education regarding how to give and receive critics.

Idea 2

During re-training or some other collective time, the standardized work instruction should be evaluated. If operators have found a better way of performing the work task this method should be discussed and tried within the team. Re-training is necessary to have each week due to the large amount of new personnel that circulates within the shop floor. This could contribute with that everyone has a chance to learn from each other.

Idea 3

Perform the follow-up similar to the 5S audit, which means that at a set time the team perform self-monitoring and sometimes perform monitoring on another line. The follow-up could also be performed by the shift leader or a mentor according to a schedule. During the follow-up, operators should discuss improvements they have found at the line. The result from the follow-up should be reported to AMG. It is essential to increase the understanding among operators why it is important to work according to standardized work instructions.

Idea 4

The team perform self-monitoring and at a regular interval so will the AMG leader. AMG leader could do random sample at line during their board walk. Each team needs to discuss the deviation from standardized work instruction to find the best way of performing the work task. In order to do that, deviation notes should be written and when they are accepted and when operators work in a similar manner, these could be removed. When operators do not work according to standardized work instructions, a discussion needs to be held to evaluate if their work method is better than the standard. If it is not and the operator continues to not follow standardized work instruction, disciplinary measure needs to be taken. The follow-up should also be performed at a regular basis but when the operators are unaware of this.

Idea 5

Different levels within the company should perform follow-up, as well as shift leaders and mentors. The follow-up has to be time efficient and not be to administrative. Education regarding standardized work instructions among the operators is important to perform follow-up internally.

Idea 6

The mentors within the team should perform follow-up, this should be done each week. It is important to educate the operators regarding standardized work instructions and also be consistent when standardized work instructions are not followed. This is done by giving operators a verbal warning and after that a written warning. Operators need to respect each other and discuss their work environment. An understanding that follow-up is important is crucial to establish among operators. To increase awareness regarding standardized work instructions, operators should be educated and then perform a knowledge test.

Idea 7

The follow-up could be performed during total productive maintenance each week. The team should discuss the instructions to make sure that they are working according them. Operators should also be tested at the line during this hour. This is done by following the instruction step by step at each station. In order to be efficient, teams should be divided into smaller groups and discuss improvement ideas and also discuss how to follow standardized work instructions.

Idea 8

The person that is responsible for standardized work instructions together with AMG leader and shift leaders should perform follow-up in a regular interval. They should always take actions when they notice that operators deviates from standardized work instructions. The follow-up should not be scheduled; it should be performed different days at different times. The follow-up could also be made by a mentor that has received training from the production process engineer; this is so the production process engineer gets more involved in the daily activities at line.

Idea 9

When follow-up is made and the standardized work instructions are not followed, make sure that the instructions are updated otherwise educate the operators that are not working according to standardized work instructions. If the instructions are not followed, do an Avix analysis and involve operators. With the movie as a foundation, discuss improvement that can be made and learn from each other.

14.2 QUESTION 2

How should operators be involved in the development of standardized work instructions?

Idea 1

Perform an Avix-analysis workshop together with the whole team to mutually develop the best ideas that includes individual freedom in the work. The operators then try the standardized work instructions and then find the best balancing. The production process engineer writes a draft on new standardized work instructions after the best balancing is developed; this is later tested by more individuals in the team. The team is allowed to assess the standardized work instructions both prior and after they are changed to ensure that the change is toward the better. After that they mutually decide on which work procedure that is best.

Idea 2

One designated person in the team is educated on how to write standardized work instructions but everybody in the team are allowed to influence the outcome. Improvement proposals from the team are taken care of and are adapted to the team's wishes through the designated person. This person later writes and or updates the standardized work instructions. The production process engineer audits the draft of new standardized work instructions and updates it if necessary. Then the standardized work instructions are tested by one operator. The team is allowed to try the new standardized work instructions for a week and then decides if it is good enough. They are allowed to reject the newly proposed standardized work instructions.

Idea 3

Describe the work procedure in the standardized work instructions in the way that the operators would describe it on their own, so that it is the operators' language that is used. Standardized work instructions should be visualized with a movie that shows the differences between work task procedures in a good way. After the movies are developed the production process engineer should make a draft on new standardized work instruction together with one designated operator from the team. They should later test the standardized work instruction to ensure that it is working correctly. The work procedure could be described both with a movie and on a paper. The movie could be used for education of new personnel and when re-training of experienced operators.

Idea 4

Make a movie on different work task procedures to make it easier to see the differences between the procedures. In the development of the movie, all operators should be involved. A dedicated trainer would then educate the operators and also develop the standardized work instructions. To use a dedicated trainer would mean that extra resources are needed.

Idea 5

Production process engineer starts writing a draft of the standardized work instructions that the team later evaluates and comment. Thereafter, the production process engineer finalizes the standardized work instructions. Designated operators in the team are allowed to assess the standardized work instructions and when there is a need, give feedback to the production process engineer. He or she will then update the final version of the standardized work instructions. Designated operators in the team teach the rest of the team members the final version of the standardized work instructions. Film different work sequences to show good and bad movement for ergonomics, this is so that all team members understand why and how to perform different movements.

The movie should also include how to be as productive as possible. It is important to be able to show a movie at the line in an easy way.

Idea 6

Production process engineer gives someone in the team the task to develop standardized work instructions within the given framework. The production process engineer reads through the standardized work instructions and gives feedback. Educate operators and mentor the importance of working according to standardized work instructions and also ergonomics. Use practical examples at the line, why a certain work procedure is the best.

Idea 7

Let operators be a part of developing the best work procedure. The team needs to be on a common ground regarding the best working procedure. The operators need to discuss and work according to different procedures to be able to develop the best one. This should be done in controlled forms, at regulated time intervals to make small modifications at a time. Test new work task procedures on one operator during a regulated time interval. Educate and make practical test on line to increase the understanding among operators regarding work task procedures.

Idea 8

Ask the operators to read through and give feedback on the drafts for new standardized work instructions on a regular basis. Or it might be enough that the mentors, who are going to educate operators and re-train experienced operators, give feedback on the drafts. The production process engineers could use the mentors as a sounding board. When re-training is done, all operators should be gathered close to the work station and the standardized work instructions are read through and followed.

Idea 9

The mentor role could supply with information to create basic data for the development of standardized work instructions. The mentor could set the framework of the standardized work instructions but not set all details. Make sure that extra attention is paid to operators and make sure that they receive education regarding best work procedure. It is also important to increase the level of following the standardized work instructions. Methods to ensure that the standardized work instructions are followed needs to be created. Create a visual board where all operators', in the team, competence level is displayed.