# THE IMPACT OF INFORMATION PRESENTATION ON WORK ENVIRONMENT AND PRODUCT QUALITY: A CASE STUDY

Gunnar Bäckstrand[1,2,3 *], Peter Thorvald[1,2], Leo J De Vin[1], Dan Högberg[1], Keith Case[1,2]

1. The School of Technology and Society, University of Skövde, Box 408, SE-541 28, Skövde, Sweden.
2. Mechanical and Manufacturing Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK.
3. Volvo Powertrain AB, SE-541 87, Skövde, Sweden.

## ABSTRACT

In manufacturing, it is vital that production personnel have the right information at the right time and place. The main purpose of information delivered to a workplace is to support the worker in a way that contributes to the quality of the product as well as productivity. However, when information processing becomes a large part of the workload, the time for core workplace activities is reduced.

A study was conducted at a heavy diesel engine assembly line with the aim of finding how the assembly personnel interact with the information presented to them in their work context and how this affected quality and productivity.

The study focused on four assembly stations and involved 70 assembly workers over a period of ten days and nights during which 2600 standard and customised variant engines were assembled. The main feature of the study was a change in the information system that reduced the amount of data and information provided, changed the location of the information, and modified the timing of information presentation.

Results from the study show that the information presented at an assembly workstation influences the quality as well as the assembly process itself. The number of internal rejects decreased by 40% on two of the stations and on the other two stations no errors occurred during the study. This influence on the assembly process is of great importance from a quality perspective; by changing the information system and thereby the workers' behaviour, the errors were reduced significantly. Whilst errors are few and detected internally, redressing these errors is a waste. Furthermore, an adequate information system boosts operator confidence and reduces cognitive stress levels.

The information system used in this study was relatively simple (simpler than the regular system) and based on colour coded cards. Nevertheless, the impact was major and this indicates that when designing an information system for mass-customised assembly, a wide range of solutions needs to be considered. A study in final assembly of heavy trucks is planned for the future where the ultimate goal is to arrive at worker and task tailored presentation of information in customised assembly.

**Keywords**
Production, Information usability, Cognitive ergonomics, Workplace design, Assembly quality

# 1. INTRODUCTION

Volvo Powertrain in Skövde, Sweden manufactures heavy diesel engines used in trucks, excavators, articulated haulers, boats etc. The engine assembly represents mixed model production. In the main flow, a high volume product is assembled, but there are also low volume products assembled, intertwined with this product flow. To handle this situation a dynamic information system is essential so that it can (for example) refer to parts to be assembled on a specific engine, information regarding how to assemble a particular engine, etc. In the plant studied the information system is implemented as an IT system mounted on the Automatic Guided Vehicles (AGVs) that carry the engines down the assembly line.

The aim of the study is to find evidence that supports the overall aim of the research which is to find or develop a prototype work method that supports the design of information flow based on product and process demands. The knowledge gained from the is expected useful in the next stage of the research which is the creation of a prototype work method.

Earlier work (Bäckstrand et al., 2005; Bäckstrand et al., 2006) indicated that the personnel do not always use the information system in an appropriate way. If the personnel do not use the system in a way that the system designer anticipated the risk of quality problems increases. In the previous study there were no investigations regarding how and if this would affect the quality, the focus was to understand more regarding how the assembly personnel interacted with the information system and how they used the presented information. There was more than one intriguing outcome from that study, and the most interesting one in this case was how “Time” could trigger different assembly behaviours, or rather how time influenced the choice of assembly strategy among the personnel. The design of the system in the study made it rather easy to evaluate if time was an important parameter and if it influenced the quality as suggested in the 2005 study.

The main objective with the current study was however not to evaluate the time influence, but rather it was to find out how the same information presented in a different way can influence quality.

# 2. STUDY AND METHOD

The study was conducted over a period of ten days and nights. During that time, approximately 2600 engines were assembled. The assembly line studied contains twenty-three assembly stations and is balanced so that every station has approximately eight minutes of assembly time, i.e. the assembly personnel have eight minutes to accomplish the assembly task. The work process for the assembly personnel starts typically with an AGV arriving at an assembly station. The subsequent steps in the assembly process are (1) Identification of part to assemble (depending on station, this step can differ), (2) Retrieval of part to assemble, (3) Assembly of part onto engine. Steps 1 to 3 are repeated until all parts are assembled. (4) Confirmation of task - the personnel confirms via the IT system that they have completed all assigned tasks at the station. (5) AGV departs from the assembly station to the next station. Step 1, “Identification”, involves gathering of information. The information is presented to the personnel via a computer screen and is visible when the AGV arrives at that assembly station. During the study, the information was complemented with information from the simplified information system.

The current study was divided into four stages/phases: 1. Preparation, 2. Performance and gathering of quantitative data, 3. Qualitative evaluation, 4. Evaluation of data. In the preparation phase a large set of data from the quality measuring system work was used as a basis for deciding where within the assembly plant the should be conducted. This data also served as a reference performance indicator (Aerts et al., 1997), for the quantitative evaluation of the results. Phase 2 was conducted within the assembly line. The main element at this phase was the simplified information system, the Colour Coding system that was applied to the AGVs and at the workstation (Figure 1). This system was the actual information system used during the study.


*Figure 1:* The pictures show the Colour Coding system that was used in the study.

The colour markings on the AGV tell the assembler what parts, in this case four distinct types of parts, to assembly on the engine. The system contained coloured magnetic rubber sheets attached to the AGV. The three markings on left side on the AGV are information that the assemblers use when the engine is at the first two of the stations and the right one is information for two stations later in the line. The sheets have five different colours - blue, pink, orange, green and black and they inform the personnel at the station what part variant should be assembled on the specific engine. The same colours were found on the material racks; see right part of Figure 1. The rubber sheets were applied at the beginning of the assembly line and the data that controlled which colours to use were the same that was used by the existing system. The process of applying the sheets continued, as mentioned before, over a period of ten days. The existing quality system (continued) gathered data from the four stations during the period.

Phase 3: Some parameters, such as Time and stress levels (that could trigger different assembly behaviour) could not be measured by using the historic data. To gather information regarding how the assembly personnel had been affected by the system and if they thought that the system had any influence on quality, behaviour and Time a questionnaire was handed out to 171 (response rate, 100%) persons that had been directly or indirectly affected by the study. 70 out of 171 were directly affected by the study (they worked at one or more of the four stations).

Phase 4: The data was evaluated by comparing the performance indicator before and after the study. As mentioned earlier, this indicator is a part of the reject handling system and had previously been measured for approximately 9 months during 2006. The data gathered during the study was compared with the performance indicator. After the data had been compiled, (unstructured) interviews (Breakwell, 2000) were performed with the purpose of verifying and validating (Patton, 1990) that the data hade been gathered and compiled in a correct way. Participants were quality coordinators, production technicians, and an assembly line manager.

Triangulation, in this case the use of both quantitative and qualitative methodology, is described as the comparison between data collected through a qualitative method with data collected through a quantitative method (Patton, 1990). There are two forms of triangulation, within-method and between-method, and this study is a between-method study where quantitative and qualitative methods are combined to interpret and study the data retrieved from it. The reason in this case to use a combination is to minimize the uncertainty that always exists when a human is a part of a reporting system, in this case the internal reject system and by doing that create reliability (Björk and Ottosson, 2007) that is higher then if just a single method study hade been conducted.

## 3. RESULTS

The use of the simplified Colour Coding system resulted in the reduction of internal rejects for category "Wrong parts assembled" by 40% on two of the assembly stations and to zero on the other two stations. When the use of the colours stopped, i.e. when phase 2 was over, the rate of internal rejects rose and surpassed, for a period, the reject levels before the study. After a few days the rate stabilised at the levels before the study.

In the qualitative part of the study, questionnaires and interviews, some interesting results were found. In the questionnaire, 56% answered that the Colour Coding, e.g. the colour Green, was easier to understand than the text viewed on the computer screens, 7% answered that "20824541 Servopump" was easier to understand than a Colour Code. On the question (translated from Swedish) "did you feel secure with the Colour Coding that was used on station 800 and 1100?" 76% answered "Yes" and 7% "No". 87% answered "Yes" when asked if the information that the Colour Coding provided was the information they needed to do the assembly task, 10% answered "No".

The interviews with the quality coordinators, production technicians and the assembly line manager revealed that there had been a change in the assembly behaviour, a change in their assembly process. This change is important because it lowered the use of an assembly strategy and a potential quality risk that is rather common within assembly called pre-work. This pre-work is not accepted from a quality perspective but can be effective from a productivity point-of-view. The effect of the behaviour change was that the personnel did not prepare a number of parts to assemble in advance, i.e. instead of preparing (gather, assemble gaskets etc) different parts, for up to four different variants, they prepared one and the preparation work did not start before the AGV was on its way to the assembly station. This greatly diminishes a quality hazard that can be of great importance depending on the parts to assemble. The potential problems that can occur if pre-assembly is used are numerous, but for example dirt can pollute the product, and once one has removed a part from its packing it can be difficult to find the part identification which increases the risk of assembling the wrong part. It is difficult to quantify the quality risk, it varies from case to case, but the use of the FMEA (Failure Mode and Effects Analysis) (Price and Tylor, 2001) methodology can at least give an idea of e.g. the probability of occurrences and thereby it is possible in some sense to quantify the quality risk.

Time was a parameter of interest in the study. Time in this case might be a little misleading and perhaps "Timing" is a better word. Nevertheless, the timing regarding when a person has access to the information has been shown to be of importance. The existing system provides information to the assembler after the engine has arrived at the assembly station, and the system used in the study provides information all the time and at the latest is visual for the assembler when the AGV leaves the previous assembly station. This influences, according to the questionnaire, the interviews and the discussions, the personnel in a way that decreases the stress levels and increase the feeling of control over the situation.

## 4. DISCUSSION AND CONCLUSIONS

The aim with the study was, as mentioned earlier, to find how the quality is affected by the personnel's interaction with the information system. The results from the study clearly show that the quality is affected by how and when the information is presented. The information presented at the assembly stations were the same as before, after and during the study, although the way it was presented differed. This together with the change in timing is the main reason to the rather large decrease in internal rejects. The different ways that information was presented decreased the amount of information from approximately 19 rows of text to three colour rubber sheets, and by that one has a “LEAN:er Information Flow”(Hicks, 2007). It is important to understand how a decrease of information can affect the quality positively in a way that decreases the specific problem by 40%. One way of looking at the problem is that too much information creates noise and that noise is a burden for the assembler. The system used during the study eliminated some of the information and thereby made it easier for the assembler to identify the important parts. That is why it is possible to say that the amount of information was the same before, during and after the study, and the decrease of information during the study is actually not a decrease of information, it is a decrease of noise that made it possible to find and act upon the information that the assembler really needs to fulfil a task. This together with direct connection between the information presented and where in space the parts were located made it easier for the assembler to act on the information. The presentation and timing of the information made it possible for the personnel to have a much better control over their work tasks and thereby they felt more secure in their work environment. This is evident when studying the results from the questionnaire and the interviews and therefore is it believed that the change in the information system changed the workers’ behaviour through a reduction in cognitive stress levels.

The conclusions from the study are that there is a direct connection between information and quality and that connection is related to the amount of information presented, the timing, and in what way the information is presented. These conclusions will be useful in future work that aims on developing a work method for evaluation of information need in an assembly work context.

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