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Initiation of an Evidence Based Process for Joint Optimisation of Ergonomics and Productivity in Engine Assembly

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Abstract. This paper examines the initiation of a new ergonomics process to reduce musculoskeletal disorders in a manufacturing company. Researchers acted as collaborators while applying strategies of evolutionary development, coupling of ergonomics and productivity objectives, and encouraging consideration of evidence in decision-making. Lack of indicators, especially regarding ergonomic risk factors and process functioning, pose developmental challenges. This approach has fostered the development of a process that is increasingly engaging engineers and other stakeholders in managing ergonomics throughout the production system. The developmental strategies applied in this project appear to be working.
Keywords: Ergonomic intervention, organizational culture, change process initiation

1. Introduction

This paper provides an early report on the evolution of a new ergonomics process within an organisation. This can be thought of as a close examination of what happens in the 'liquid phase' in Lewin's (1951) unfreeze-change-refreeze model. Examination of process with regards to ergonomics is particularly important since, despite many successful case studies, researchers have had difficulty demonstrating systematic effects of 'ergonomics interventions' in complex industrial systems (Westgaard & Winkel 1997). Since few of these studies included process evaluations, it is difficult to determine why these projects had no major impact on disorders. While intervention in organisational culture seems to give an effect (Westgaard & Winkel 1997), there is a need to better understand how ergonomics – a term used here to denote both physical and psychosocial aspects of work causing musculoskeletal disorders (MSD) – can be better managed through improved company dynamics. Thus, we are conducting a formative analysis of a process specifically designed to reach deeply into the organisation to engage engineers and managers who control risk factor exposure patterns

in the production system (Neumann et al. 2002) but are not generally responsible for 'ergonomics'. How, we ask, did the new process evolve? Was the process able to successfully engage key decision makers and designers to include ergonomic criteria in their development processes? What barriers and assists appeared to influence process uptake?

The impulse for this work came from concern inside the company, an engine manufacturer with a high profile in Swedish industry. The company had recently installed a line-based production system after over a decade of using individual 'dock' based parallel flow assembly. A detailed system design comparison of these two systems, conducted in an earlier phase of the research project, demonstrated how strategic design decisions affect ergonomics (Neumann et al. 2003a). A simplified system model (see Figure 1) illustrates this chain of influence that can lead to operators' exposure to risk and eventual MSD in the realised production system (Neumann et al. 2002). For example, a strategic choice to reduce the frequency of material moves (left Figure 1), might result in the logistics department selecting a larger crate for the shipment of parts (system design level). Operators trying to reach components at the bottom of this crate (production system level) might then adopt awkward postures (risk factor level) that may, in turn lead to MSDs (outcome level). This hypothetical example demonstrates how both productivity and ergonomics outcomes can be intertwined in the production system development process.

In the current project phase, senior managers and other key stakeholders wished to generate improvement actions based on the researchers' system analysis. The system in question produced the companies largest selling motor and had, consistently, elevated rates of disorders and employee turnover compared to other departments in the company. At this point, the senior production manager made a clear vision statement: *"operators should be able to continue to work in these systems up to retirement"*. The researchers and company jointly obtained funding for a research and development program with the objective to develop *"an evidence based change process which can increase the companies own ability to create a sustainable work system by optimising both effectiveness and ergonomics"*. As part of the project, the company has agreed to spread knowledge gained from the process to other industries in Sweden.

2. Methods / Program Theory

The research team adopted an action research stance throughout the project. *"You're the ones driving the bus, we can take part, but you have to take responsibility for the process"* was the message provided to company stakeholders. This balance was intended to foster learning in the organisation while avoiding that the new process be dependant on the researchers. Through a series of meetings a process was formed without an a priori 'blue-print' of process structure. This was intended to allow the new process to capitalise on existing processes while minimising redundancies and possible role-conflicts. Researcher participation included attendance at meetings and also ongoing discussions with key stakeholders regarding the formation of the process. Through these discussions we, as researchers, began to operate in the role of 'organisational activists' (Jensen, 2002), or navigators, in the effort to establish broad support for and participation in the process (Gustavsen et al., 1996).

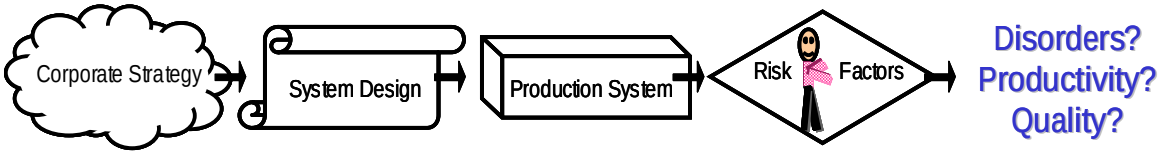

Figure 1: *Simple systems model illustrating how strategic and design decisions influence both ergonomic and productivity outcomes.*

Cross-functional teams were encouraged as a way to increase communication across functional boundaries. Special emphasis was placed on engaging production engineering in incorporating ergonomic objectives in their work. Engineering groups have particularly strong control of the time elements of risk exposure (Winkel & Westgaard 1996, Neumann et al. 2002) and have considerable leeway to affect ergonomics in the design stage where costs are minimal. Participation of operators was also encouraged. Throughout the developmental process, the desire to improve both ergonomics and productivity simultaneously was emphasised. We believe this pairing of core business performance and ergonomics is a useful approach to improve goal alignment and create opportunities to engage in joint optimisation of ergonomics with other performance factors (e.g. Gustavsen 1996).

The research team encouraged adoption of an 'evidence based' strategy, focusing on both physical and psychosocial factors, to support the companies' evaluation and decision-making processes. While most companies have good productivity and quality measurement systems, few have established indicators for physical workload or other MSD risk factors as leading indicators for MSDs. Initially the 'evidence' produced by the system comparison analysis conducted in the 1st phase of the project (Neumann et al. 2003) provided a springboard on which the development team could build. The use of quantified ergonomics indicators was seen as one way to 'anchor' the process into existing quantified control mechanisms already in use by management.

In the research project we applied these process strategies; evolutionary development, coupling of ergonomics and productivity, and promotion of the use of 'evidence', in a series of discussions and meetings with company stakeholders in an attempt to integrate ergonomics considerations as broadly as possible into regular operational procedures. Ideally, this process would include some kind of self-evaluation capability a so-called double-loop learning process (Argyris 1993), so that the production ergonomics process itself could continue to evolve without researcher input.

3. Results

The main process structure that emerged is presented in Figure 2. The process was initiated with the formation of a steering group, with representatives from many organisational stakeholder groups including production managers from other product systems. The initial meeting included discussion of objectives of the initiative and a review by researchers of the analysis conducted in phase 1. The steering group was seen to be too large to effectively develop specific plans. A temporary 'Analysis Group' was formed and charged with assessing current evidence and identifying priority areas for

action. This temporary group included a single representative from each functional group. In a series of discussions, the analysis group managed to decompose the production ergonomics 'problem' into manageable elements and cluster these elements into related aspects that could be addressed separately.

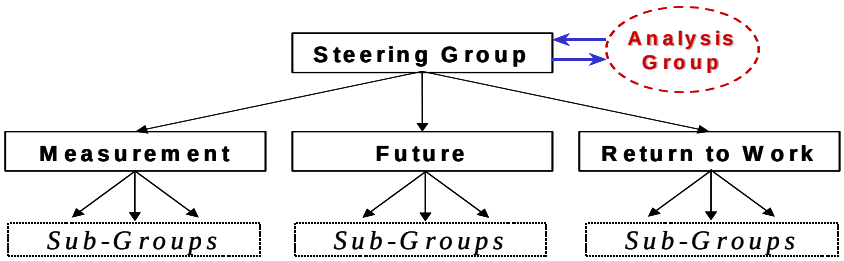

Figure 2: *Schematic groups formed during the ergonomics process initiation.*

The analysis group recommended creation of 3 groups (Figure 2): 1) a "Measurement" group' responsible for improved information (evidence) handling, 2) A "Future" group to develop improvements to the work organisation and the production system, and 3) a "Return to Work" group for faster rehabilitation. As these groups involved additional people, it was necessary to 'recruit' them into this new process.

While acceptance of ergonomic objectives is clear from health & safety for example, it was initially less clear that industrial engineers were prepared to adopt and internalise the ergonomic criteria implicit in this project. Lack of 'concrete' measures of ergonomics was seen as one of the problems in applying ergonomic criteria in design. It became one of the 'Measurement' group's first tasks to identify measures of physical loading that can provide leading indicators of MSD risk. Time availability of personnel was another barrier in the development process. Using 'alternates', someone who could attend meetings and act as a backup, helped somewhat. To some extent, the groups that formed were reformations of previous or existing groups. In these cases, formation and activity initiation was easier and faster than for groups that were entirely new.

Initially the Steering Group asked each of the 3 groups to set goals, with a special emphasis on measurable objectives. While the emphasis on quantifiable objectives is consistent with other aspects of the companies' management approach, it posed a challenge for some of the groups. Some groups, faced with the task of 'setting goals', tended to lean on the research group for specific language formulations. Other groups set clear goals framed in a qualitative way. For example, the 'return to work' group had a verbally expressed objective to "*establish a more powerful return to work process*". While this goal is specific enough to guide action, performance indicators still need development. The goal setting process also highlighted interactions between the development groups: It would be difficult, for example, for the 'Future' group to demonstrate the physical load-reducing properties of a new lift assist before the measurement group has established preferred indicators. Here we see the process problems caused by the absence of indicators from the risk factor level of the system (figure 1). While the desire for "concrete" outcome measures is understandable, evaluation science (e.g. Rossi et al. 1998) suggests that qualitative assessment and indicators of process function can usefully support process development. Is it possible that there is a conflict between the desire for goals and practical development needs?

The tasks given to the three groups (Measurement, Future development, Return-to-work) were too large for these groups to handle directly. Instead sub-groups began to

form to tackle specific problems or activities. These sub groups often included additional personnel, such as group leaders who were often more directly connected to floor level operations. It is at this sub-group level where actual changes and development work appeared to occur, while the higher-level groups were more focused on strategic issues, problem definition/decomposition, goal setting, and coordination.

At this point the role and make-up of the steering group, which at various times was also called 'Action' group and 'Strategy' group, is also evolving. There is a desire to engage the senior management team in the developing process as it reaches more broadly into the organisation. This may be helpful in establishing support for the initiative throughout the organisation, not just inside the production department but also in the engineering groups. Over the long term, senior manager participation is needed if the objectives of this program are to be integrated in core corporate goals. The role of senior management in monitoring and strategically shaping the process also remains unclear at this stage. There is, for example, a desire to connect this initiative to the company's development of the latest production system for a new engine model. This provides tremendous potential for improvement since there are few constraints early in the system design process. It also poses a coordination challenge since the experience and knowledge of the development groups must be harnessed in a timely fashion by the design team. This demonstrates the trend we see of the process gradually penetrating deeper into the organisation.

4. Discussion and Conclusions

The development of the process described here remains highly dynamic – changes in structure are ongoing posing a challenge to process description While specific 'ergonomic' improvements have already been implemented, long-term success is not certain. We intend to continue this longitudinal case study. At this time the following concluding statements appear justified:

Use of an emergent, or developmental, strategy with cross-functional teams appears to help integrate ergonomics into the organisation. It can take advantage of existing organisational context such as structures or individual capabilities. It also builds links between groups and individuals needed to solve problems, such as those of ergonomics, which span many domains.

A strategy of jointly optimising productivity and ergonomics has assisted in securing support from stakeholders not traditionally focussed on ergonomics. This is consistent with other development projects (Gustavsen et al. 1996). The extent of engagement of various engineering groups is growing but remains varied. The process is expanding in a middle out pattern, gradually engaging the workforce directly in improvement process - a trend consistent with positive results (Gustavsen 1996).

Goal setting and indicator development should both be considered tasks for development.. Quantified indicators, particularly of ergonomic risk factors, are still needed to support of the process. Group members should also consider process indicators to diagnose process functioning – not just outcome measures. Perhaps application of broader types of 'evidence' would be helpful? A further area for development with regards to 'goals' and 'evidence' should include developing the ability to evaluate and re-develop it's own process – double loop learning. While a

project champion might identify opportunities to improve, there must also be an adaptive mechanism to foster ongoing process development.

Ergonomics poses a special challenge to development work. Unlike quality, indicators are not well developed. Furthermore, while real control over risk factors is distributed broadly through the organisation by those influencing production system form and function, responsibility for ergonomic problems has traditionally been directed to specific groups like the health service. It is this organisational 'gap', between influence and accountability, which this process appears to be gradually closing. .

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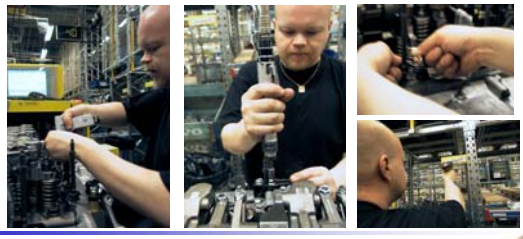
VOLVO

WMSDs - Scope of Problem

- **~4% *Gross World's National Product* (GWP) to Work-related ill health (WHO 1999)**
  - **~40% Musculoskeletal Disorders**



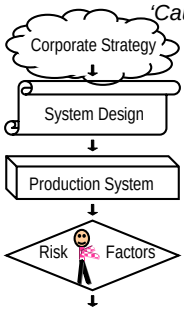
OLD
'DOCK' Station

NEW
'LINE' System

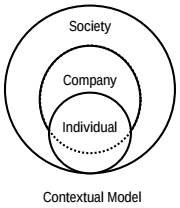
System Model

'Causal Cascade'

Management
Industrial Engineering
Production Staff
Individual
System Outputs



Disorders, Productivity, Quality? (DPQ)



Contextual Model

OLD
'DOCK' Station

NEW
'LINE' System

Management's Vision

"operators should be able to continue to work in these systems up to retirement"

Program Objective

"an evidence based change process which can increase the companies own ability to create a sustainable work system by optimising both effectiveness and ergonomics"

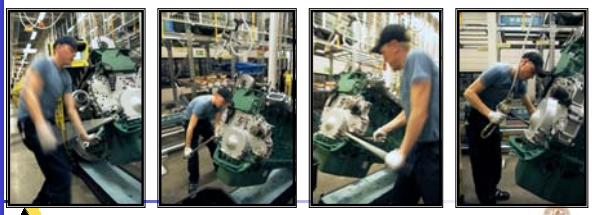
Strategic Map

Ergonomics

Productivity	Better	No Change	Worse
Better	*Go!*	OK	False Profits?
No change	OK	◆	X
Worse	Hidden Gains?	X	X

Process Strategies

1. Evolutionary Development: "Grow to fit"
2. Coupling of Ergonomics & Productivity
3. Evidence based decision making



Methods

- ACTION RESEARCH
  - Directly engaged as 'Political Navigators' (c.f. Broberg - DTU)
  - Project Control in COMPANY hands
  - Field notes of Discussions
  - Tape recorded meetings
- FORMATIVE EVALUATION
  - How can we stimulate processes growth?
  - Barriers? Assists?

① ② ③ ④

ALI

Steering Group

D12 Dock to Line Comparison

Pre-initiation: Evidence base gathered by ALI, given to Volvo. Trust and personal networks built.

① ② ③ ④

ALI

Steering Group

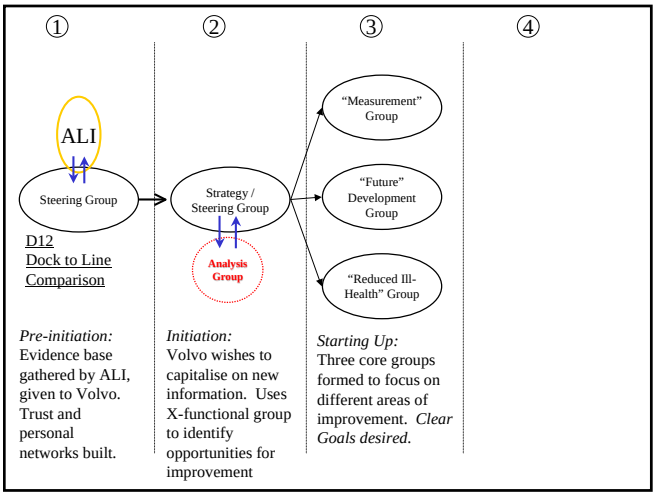
Strategy / Steering Group

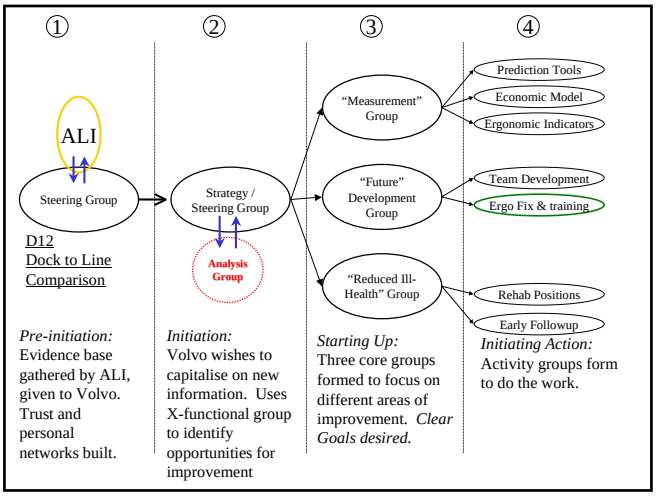
Analysis Group

D12 Dock to Line Comparison

Pre-initiation: Evidence base gathered by ALI, given to Volvo. Trust and personal networks built.

Initiation: Volvo wishes to capitalise on new information. Uses X-functional group to identify opportunities for improvement





Barriers

- ***Staff turnover – all group leaders left!***
  - Does expecting a change affect willingess to engage?
  - Do people doing good job get promoted?
- Some Org. Divisions less willing to take responsibility for Ergonomics
  - Not part of social/company role?
- Calls for 'Measureable Goals' created problems for some groups – slowed start-up *(focus on action?)*
- Visible management support?
- Alligators

Opportunities

- Establishing ergonomics indicators
- Growing awareness??
- NEW flagship system in design now seen as major area for innovation (not the exisiting system)

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