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THE NEW IMPORTANCE OF SOCIO-TECHNICAL SYSTEMS RESEARCH ON HIGH-TECH PRODUCTION SYSTEMS

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ABSTRACT

This conceptual paper underlines the growing necessity of research into socio-technical systems in modern high-tech industries. Production of sophisticated products is foreseen to build the competitiveness of the Western economies' industrial sectors in the future. Increasingly, competitiveness in such industries depends on a complex interaction between social factors such as knowledge sharing, learning and innovation and technical factors such as automation and information systems. However, up to now, improvements and developments in these industries have been clearly biased towards the technology side. Now, awareness is strongly needed in regard to the social- and work condition aspects if implementation of further technology shall pay off. This paper argues that socio-technical systems research could be a promising path when preparing for the future.

Keywords: Socio-technical systems, high-tech production systems, operations management, work practice

BACKGROUND

The paper is written as a conceptual point of departure for a four-year, 4 million € research project funded by the Norwegian Research Council. Two industrial partners are taking part in the project, which aims at creating the ideal factory for high-tech manufacturing companies: Kongsberg Defence & Aerospace (KDA) and Volvo Aero Norway (VAN). KDA develops and produces high-tech products within communication systems, weapon systems, commando- and control systems and advanced carbon composite materials. VAN is a manufacturer of high-tech airplane engine components. Both companies are global players and deliver to highly demanding customers such as the US Department of Defence, Pratt & Whitney, General Electric, Snecma and Airbus to mention a few.

This paper is a conceptual paper, based on insight from the industrial partners together with relevant theory. The main differences between past and future working conditions which affect modern high-tech production systems can be discussed under three headlines:

(1) Future competitiveness goes beyond technology

(2) Fully integrated information chain from shop-floor to top-floor

(3) Automation alienation, competence gap and attractiveness of work

Both Kongsberg Defence & Aerospace (KDA) and Volvo Aero Norway (VAN) provide practical examples of the stated developments and their interconnected challenges.

Future competitiveness goes beyond technology

Globalisation leads to a shift in sectors, where labour-intensive manufacturing of easy-exportable products tends to be off-shored from Western economies. At the same time, knowledge-intensive manufacturing of complex high-tech products is expected to build the competitiveness of Western manufacturing industries in the future. While technology is simple to copy across company- and nation borders, work culture and tacit organisation knowledge is much harder to imitate, and can be a source for sustainable competitive advantage. Nevertheless, technology is still solely driving the innovation in Western high-tech industries.

Table 1 Industry examples highlighting an unbiased focus on technology

Kongsberg Defence & Aerospace (KDA)	Preparing for increased incoming orders, KDA decided to build a new 150 million € factory in Norway in 2008. Strikingly, the need for square meters, machinery, layout as well as the colours of the walls where decided upon, before KDA started designing the organisation and allocating the people who should actually work in the factory. Even though this shows how complexity traditionally is coped with in engineering organisations; does it secure the best fit between organisation and technology?
Volvo Aero Norway (VAN)	Preparing for increased production of complex jet engine components, VAN needed to upgrade their machinery park to include a number of highly automated Flexible Manufacturing Systems, and significant investments have been made during the recent years. However, VAN now faces challenges in regard to utilizing the full theoretical exploitation ratio of the FMS due to scarce competence resources and the learning curve. How could VAN prepare for this?

Organisation and workers add more complexity to a company than technology probably ever will. Moreover industrial companies are managed by engineers and economists, who tend to look for single-right solutions in order to simplify and justify the decisions made. Due to this, decisions on technology are often given priority while decisions on organisation and workers are treated as black boxes which are fought with after technology and frame conditions are given. As a paradox, when the technology is given and implemented (e.g. an IT-system, a CNC-machine etc) and workers are allocated to an organisation map, the workers seem to treat the technology as black boxes (Knutstad et al, 2008). This issue only increases in importance as companies evolve into high-tech, mass-customised industries, where technology is considerable more complex than in traditional industries.

Closing the information chain from shop-floor to top-floor

From a technical point of view, recent developments in ICT and business applications clearly create greater distance between the employees of high-tech manufacturing firms and the production systems. Increasing implementation of MES (Manufacturing Execution Systems) closes the information gap between automatic production systems (e.g. CNC-machines, material handling robots etc), and the ERP-systems (Enterprise

Resource Planning). Moreover, auto-ID technologies such as RFID (Radio Frequency Identification) and sensor-technologies are foreseen to lead to conditions such as Ubiquitous Computing and Internet of Things (Glover and Bhatt, 2006). In parallel, smart decision support systems such as BI- (Business Intelligence) and BAM-systems (Business Activity Monitoring) removes the very last need for top- and middle-level managers to see operators face-to-face.

Table 2 Industry examples regarding closing the information chain

Kongsberg Defence & Aerospace (KDA)	KDA is at present time implementing a MES-system in its production. The MES-system will digitalise all production plans and documentation routines, and hence move KDA towards a paper-less factory. No doubt the MES-system can reduce waste in the organisation by making the production plans and need for track & trace more real-time and effective. However, what the MES-system will introduce of new work processes between operators and managers is much less examined by KDA.

From a social theories point of view, this digitalisation of work places leads towards hyper-bureaucratisation. Hyper-bureaucratisation is a result of the increasing use of complex automation and ICT systems, because such systems lead to extensive quality systems built to cope with new complexity. Social science scholars such as Grint and Woolgar (1997) have done considerable contributions on pieces of this puzzle, but the future digitalised working situation where high-tech companies are digitally integrated, from auto-ID-labelled materials via automated shop-floor machines via MES and ERP systems to top-floor business intelligence, is not much investigated in research and calls for attention.

Automation alienation, competence gap and attractiveness of work

In parallel with the development of IT-applications, the focus on automation in Western manufacturing industries continues. However, automation is also moving toward the extreme, and several industries are now experiencing what can be called the second generation of alienation in companies related to the man-machine interface. The fist generation of alienation was when CNC-machines (Computer Numerical Control) and later on FMS (Flexible Manufacturing Systems) replaced the manual turning lathe or the milling machine, and operators starting feeding and emptying the machining centres while else passively supervising them. The second generation of alienation is now taking place as AGV (Automated Guided Vehicles) and material handling robots are removing the very last of physical operations. Operators are not operators any more, but still far from redundant; the industry of the future has clearly a growing need for knowledge-intensive jobs in maintenance and in planning and control functions.

Table 3 Industry examples regarding automation

Volvo Aero Norway (VAN)	One of the main goals of VAN related to production is increased automation where machinery can run around the clock also with limited presence of operators. How does VAN cope with the next generation of alienation related to the man-machine interface?

Irrespective of the automation level in modern industry, there will always be a "man-in-the-circle", meaning that there will still be a need for a responsible person controlling the production system. Moreover, in high-tech industries, there is clear a need for increased knowledge also at the shop-floor level. Contrasting this, a decreased focus on attractiveness of work is evident in industry, together with an increased focus on technical and economical value added production systems. In our conceptual perspective we will argue that, in order to increase the future competitiveness, companies need to have a two-sided focus on the value creation, not only the one-sided traditional economical and technological focus. On one side they need to continue with increased value creation along the track of advanced utilization of technology and operation management. On the other side the companies need to increase value creation along the line of Quality of Work Life. First and foremost to secure the need of building learning and development capacity to ensure further value creation and to keep up the competitive edge.

Table 4 Industry examples regarding attractiveness of work

Kongsberg Defence & Aerospace (KDA)	KDA's increased demand for high-skilled work force is putting the relationships to nearby engineering companies to the test: In the industrial area in South-Eastern Norway where the companies

	operate a limited work force pool of engineers is available. Besides the fast-growing salaries, factors such as attractiveness of work and employer reputation are playing increasingly important roles in the search for engineers.
Volvo Aero Norway (VAN)	According to VAN's 10-year strategic technology plan, the competence profile of the company will make a considerable switch towards a high-skilled work force in the next years. How can VAN coordinate an optimal mixture of running production and continuous learning and certifications?

THEORY

Originating in the automobile industry, Lean describes in detail practical techniques and methods that promises higher degree of effectiveness and increased competitiveness for the companies leaning on the concept. Authors of Lean production have been recognising human factors since its beginning (Womack et al, 1990) and Human Resource Management is just as an important part of Lean as Just-In-Time, Total-Quality-Management and Total-Productive-Maintenance. Toyota's concept of Jidoka, which can be defined as "working with machines" (Baudin, 2007) describes in detail the man-machine relationship from a technical point of view. Cross-functional training of work force, self-directed work teams and employee empowerment has been emphasised as key for success in JIT, TQM and TPM (MacDuffie, 1995, White et al 1999).

However, worker empowerment requires increased worker skills, which might not always be apparent. Increased shop floor responsibilities and stress together with strict focus on less waste and faster production has led to the discussion on whether or not lean is actually "mean". Put to the edge, the main aim in Lean production is to eliminate all waste in terms of organisational, social and technical waste. This tends to lead to a reduction of resources allocated to organisational learning and development, because their contribution to value creation is often hard to see and define. Opposite to this, socio-technical systems research emphasise organisational flexibility and continuous worker learning and development (van Eijnatten, 1993; Dankbaar, 1997). De Sitter et al. (1997) stress the need to build simple and flexible organisations with complex knowledge-intensive jobs, instead of building complex organisations with simple and specialised jobs.

The socio-technical systems (STS) approach has its origin in the early work of Trist and Emery at the Tavistock Insitute of Human Relations (Trist, 1981). The theoretical development of STS began with the study involving the coal-mining industry in England. These studies revealed that the use of self-managed work teams improved both the performance and the psychological well-being of the workers (Trist & Bamford, 1951). It grew as a result of apparent short-comings in the previous eras of work organisation and management. Taylor's Scientific Management focused on the mechanics of management and organisation and tended to ignore the human side of manufacturing. The next landmark era of management, the Human Relations movement, focused more on the human side, omitting, for the most part, the technical considerations of manufacturing.

The objective of socio-technical systems was to define a structure that responded to the requirements of the job tasks and the technologies, as well as the psychological needs of the people involved. Furthermore, given the interdependence of systems and the environment, the socio-technical approach attempted to structure the system of work so that it could respond to changing external demands in a rapid and flexible manner. Some of the most famous experiments in group working in the 1960s and 1970s took place in Scandinavia (Trist, 1981). The Norwegian Industrial Project from 1962-1969, resulted in several field experiments where self-managed work groups where implemented as alternative forms of organisation to increase participation and reduce alienation of work (Emery & Thorsrud, 1976).

Even though Trist and Bamforth (1951) introduced the term socio-technical in a production system context, there has been a shift away from the technical towards the social aspects of socio-technical in the latest decades. Today, socio-technical system theory typically deals with topics such as motivation, process improvement, job satisfaction, self-managing teams, job design and enrichment, job rotation, and empowerment through communicative participation, and so on. Along this line we argue that present STS have lost its original, and important, perspective. Furthermore it is crucial to bring the origin into focus again, not by itself, but as a vital part of the two-sided value creation process that will strengthen companies' competitive edge.

CONCLUDING REMARKS

This paper argues that the work places in modern high-tech production systems would profit from being analysed from a joint socio-technical systems- and operations management point of view. Operations management aims at building better manufacturing systems that are more productive (efficient) and profitable (effective) than what we have today, whereas social research on work practice generally aims at building better work places that are more humane, attractive, educational, and that bring along Quality of Work Life workers. However, in modern high-tech industry we do not need better systems; we need new systems that are better. In order to understand and build new systems that outperform the production systems we have today, the authors see a fruitful bridging of research on operations management and work practice in order to strengthen the socio-technical systems research on modern high-tech industries.

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