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# INCLUDING SOCIOTECHNICAL ASPECTS IN VALUE STREAM MAPPING

## - LAUNCHING THE STS VSM -

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## ABSTRACT

The purpose of this paper is to explore the possibilities of extending Value Stream Mapping (Rother & Shook, 1998) into also covering the dimensions of organisational aspects and job satisfaction.  To fully exploit technology in high tech manufacturing, one also has to address the human and organizational workplace aspects.  Technology can be copied, but the level of which it is exploited depends on the less replicable employee knowledge, participation and understanding, big picture considerations, communicative skill, motivation and cooperation. Hence, working purely towards technology excellence does not guarantee success in the long run.

Value Stream Mapping (VSM) is a well proven improvement technique for achieving the goals of lean manufacturing (Womack & Jones, 1996). Amongst the advantages of VSM is the participation of workers in the development of the current- and future state maps, the visualisation and common understanding of the value creation process through a logic drawing, the quick mapping, and the fact that many people in manufacturing are familiar with the tool. However, VSM is clearly biased towards technical properties of the value stream such as inventory levels, tact times, up-times etc., all in order to get a view of the technical and economical potential in the production route under investigation. Extending VSM with socio-technical aspects is needed if the tool shall remain useful for the high-tech industry of the future. The challenge is to maintain the good sides of VSM whilst expanding with socio-technical aspects.

**INTRODUCTION**

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 organisational factors such as communication, knowledge sharing, learning and innovation and technical factors like automation and information systems. However, until now, improvements and developments in these industries have been clearly biased towards the technological side. Now, awareness is strongly needed towards organisational aspects and working conditions if further implementation of advanced technology is to be effective.

The contribution from socio-technical-system theory (Trist & Bamforth, 1951; Trist 1981) are primarily to build more competence, provide for all employees to see the overall picture in their value creating process, arrange for continuous improvement efforts to be more effective etc. At the same time, partly as a secondary goal and partly as a consequence of the primary goal, the work place attractiveness is increased and the workers are more motivated, and hence, to a larger degree are able to exploit their potential. This strengthens the effect a well functioning organisation can have on improving performances.  So, emphasizing socio-technical aspects in the development of the value creating process should result in better performance, and should be possible to register, for instance as increased up time, less work in progress, and so on.

Value Stream Mapping was developed by Mike Rother and John Shook (1998), using their knowledge of Toyota practice to create a simple way for managers to see the flow of value. They were encouraged by James Womack, and the result was called "value stream mapping". It was first introduced in the Lean Enterprise Institute (LEI) workbook *Learning to See* in 1998. The VSM method gives a quick and illustrative introduction to vital manufacturing capabilities. It allows for all employees to share the same apprehension of the situation through the visual presentation of the current state. As a contradiction, the description of the social-technical potential is normally given in other formats, often by words and considerations that neither is available to everybody and, nor is subject to considerations of the value stream mapping personnel. Also, parts of the organisational development toolbox are advices that are not operationalised to the same extent as tools that handle technological aspects. The picture of the social-technical potential of the value-chain should preferably be of the same type that has proven useful to the whole organization on key technical and economical aspects.

The goal of this conceptual work is to discuss the VSM-tool with respect to including organisational and work place aspects (as shown in figure 1) to get a more integrated and holistic picture of technology, work and organization.

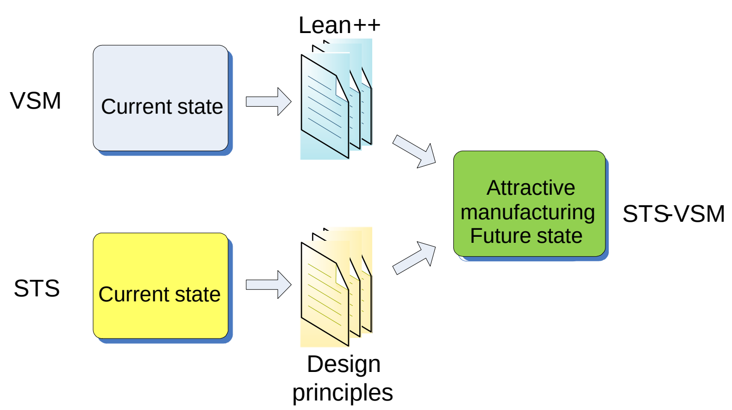


*Figure 1. Merging of two disciplines to create sustainable future state maps of the value creation process.*

The idea is to;

- Strengthen the dicipline of “organisation and work-place design” into high-tech industries development processes
- Build on existing proven methods which to some extend the participants already are familiar to
- Make organisational and social aspects more visible to technical personnel
- Merge two disciplines into one tool, to better see coherence
- Create the same type of picture for different aspects that influences the value creation process

Our research is carried out together with two Norwegian high-tech manufacturing companies. Both companies are considered world class manufacturers within their markets, and they share the common challenge of continuous improvement and future excellence through empowerment of people.

**METHOD**

SINTEF Technology and Society, together with two Norwegian high-tech manufacturers, has founded the project Ideal Factory to develop a new production concept for high-tech products. The development team includes researchers from *logistics*- and *work research* disciplines as well as industry managers and operators. The team design is chosen to create synthesis between multiple disciplines, and between academia and industry, hence creating a co-generative learning arena (Greenwood & Levin, 1998).

Our approach is to expand a well proven and well known improvement tool (the VSM) with organisational considerations to achieve a new and more powerful tool;

the STS-VSM. This is done together with the two Norwegian case companies. As many engineers are familiar with the VSM tool, one hindrance should be eliminated when building on this existing tool in which they have confidence.

Whilst within the technological domain quantitative methods often are sought, within organisational and human audits qualitative approaches are more normal. Through existing audit exercises within the case companies, recognition is gained towards both kinds of manufacturing evaluations. To overcome the difficulty of auditing and characterising the levels of which the industries perform on organisational and social related aspects today, we use a scale developed by (Meredith & Hill, 1987).

Combining the practicality of engineers with theory from other manufacturing disciplines, partners claim that the new mapping tool should be possible to inscribe to. The companies participate in the development and will serve as test-beds for the new tool. The project is supported by the Norwegian Research council.

## DISCUSSION

In order to increase future competitiveness, companies need to have a two-sided focus on value creation, rather than taking the traditional one-sided view based on economical and technological issues. Companies need to continue with increased value creation both along the track of advanced utilisation of technology and operational excellence whilst simultaneously increasing value creation along the line of Quality of Work Life. In order to achieve this, companies need to both develop the technological system and the work organisation. Our research and experiences with a number of manufacturing companies show us that there is a biased trend towards heavy investments in advanced manufacturing technology and ICT systems. We will argue that in the future advanced technology is easy to copy, by and becomes common. Whilst the way the technology is utilised through the way of training employees and organise work is much harder to copy.

Value Stream Mapping is a tool stemming from the lean manufacturing tradition. All value produced by an organization is the end result of a complex process, a series of actions that lean thinkers call a value stream (Womack, 2006). This lean tool can help companies level production, resulting in dramatic reductions in throughput time and costs, and improved quality (Womack, 2006). It is performed in the following manner;

- Select a product family
- Create a current-state map
- Create a future state map using lean techniques
- Create an implementation plan for the future state
- Implement the future state through structured continuous improvement activities

After the material flows are captured, the information flow is recorded. When drawing a map, lean thinkers create a data box underneath each step to record information on these attributes. Sometimes additional information is needed, depending on the situation, and an important reality of mapping is that every map for every value stream will be slightly different. Efforts to force every value stream into an identical format will only produce frustration. The tool is powerful to describe and visualise the value stream and its potential to utilise the machines, but has also been subject to discussions concerning its potential weaknesses. Womack (2006) points at the following;

- There is a need for a problem definition before starting the mapping. This will secure that adequate information is gathered. Otherwise, there is no guaranty that the mapping will address the real issues
- The current state map must be correct! Improvement must be based on accurate problem description. This can sometimes be a challenge for humans, working hard to make higher-level managers happy
- It is important to develop a standard method and a common language, because many members of the organisation will need to conduct value stream mapping over time
- It can be difficult to apply guidelines such as takt, flow, pull, and levelling in factories that have a high mix of products that must travel through the same value stream. In these cases, more details are needed, and preferably also some new tools. In the case companies in this research, the selected product families are the sole product in the line.

Done right, the tool can avoid randomly quality improvement initiatives and projects that don't bring any results to the bottom line. In this research, the tool, with its known weaknesses, constitute a satisfactory base for further development. VSM benefits organisations in the following way;

- Helps an organisation to visualise multiple processes at a time which gives a better overall picture of an organisation
- Provides a form of basis for an implementation plan by providing opportunities for improvements and makes improvements decisions easier

- Looks at the same VSM, this provides a common language for talking about manufacturing processes throughout an organisation
- Helps an organisation to see more than waste. Mapping helps an organisation see the source of waste in your value stream
- Ties together lean concepts and techniques
- Works as liaison between the information flow and the material flow, no other tool has such capabilities (Woll, 2003)

Our aim is to use the basics from the VSM tool to develop an integrated tool that jointly shows the current state of technology system and work organisation, and by that its future potential. This view is supported by Venegas (2008) who states; *if people are such an important part of a business process, why are people processes not reflected in some way on the value stream map?* We will argue that combining the socio-technical thinking and the basic from VSM have several advantages. Firstly it will bring the technological system back into the socio-technical thinking. This is necessary since the socio-technical systems thinking the two last decades have become more unbalanced by focusing on the social systems and the quality of work life challenges. More or less simultaneously the social-technical systems perspective has lost its connection to companies' value creation processes.

The key question is how the relationship between the two parts, the social and the technical, best can be designed in terms of creating attractive manufacturing and positive results for both parts? One attempt to an answer is a set of principles that will improve the way work is organised, that fulfil the ideal on joint optimisation. Socio-technical practitioners and theorists have developed such a set of principles for work design (Cherns, 1987).

| **Principle 1: Compatibility** |
| --- |
| The process of designing the organisation should be consistent with the goals of the design. Creating an organisation capable of adaptation requires tapping the "creative capacities of the individuals" to create a "constructively participative organisation". |
| **Principle 2: Minimal critical specification** |
| In the design of jobs, specify no more than is absolutely essential. Too much specification may inhibit creativity or adaptation to circumstances. |
| **Principle 3: Variance control** |
| Work should be designed to control variances (deviations from the ideal state) as close to their source as possible. Design work so that errors can be identified and corrected before they are fed to downstream processes. |
| **Principle 4: The Multifunctional principle** |
| Work design should avoid highly fractionalised tasks and individuals trained to perform only one type of task. Joint optimisation is more likely in the presence of multifunctional workers with flexible task assignments. |
| **Principle 5: Boundary location** |
| Departmental boundaries should be drawn to encompass tasks that are temporally (sequentially) related to one another as opposed to technically similar to one another. Organising work around the product flow facilitates information sharing and encourages ownership and responsibility for within department tasks. |
| **Principle 6: Information flow** |
| A key category of information is feedback on performance about variances (deviation from the ideal state). The information system should provide workers with the feedback they need to control variances and improve their process. |
| **Principle 7: Power and authority** |
| Those who need equipment, materials, or other resources to carry out their responsibilities should |

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|---|
| have access to them and authority to command them. In return they exercise the power and authority needed to accept responsibility for their performance. Power and authority also accompanies knowledge and expertise. |
| **Principle 8: Support congruence** |
| Social support structures such as reward systems, the selection process, training policies, conflict resolution mechanisms, and the like should be consistent with the objectives that governed the design of the work system. |
| **Principle 9: Incompletion** |
| An organisation design process is never finished. It is a continuing process. |

**Table 1 Nine STS design principles**

The mapping should reflect these areas, and add valuable information to the development process of the future map.  In essence, these principles form the underlying fundamental platform for the design of socio-technical systems. The study of Trist and Bamforth (1951) revealed an alternative way of organising work and utilising technology.  The results are going to influence the development of the future state map of the value creation process both with respect to attractive work places, but also to further develop the process capabilities.  This research wants to exploit the possibilities to create pictures of the socio-technical aspects.

To be able to fulfil the aim of this research we have made an adoption from Shani et al. (1992) and integrated their work with the nine socio-technical design principles. Shani et al. (1992) argue that most studies of organisational aspects of production technology have been based upon a notion of traditional technologies. Advanced manufacturing technologies may be distinguished from traditional technologies in terms of their capacity to store, process, and relay information; the capacity to improve quality of self monitoring, self regulation, and self-correction; the capacity to be easily modified during process or product production; and the capacity to be integrated with other production equipment and systems (op.cit., p. 94). For our purpose, the critical characteristic for classifying advanced manufacturing technologies is the level of integration they imply. Meredith and Hill (1987) distinguish four levels:

**Level 1 – Stand alone**. This level represents stand-alone hardware that is commonly controlled by self-contained computers. Likely hardware to fall into this category is NC machine tools, robots, and other equipment with highly limited and local information requirements.

**Level 2 – Cells.** This level represents groups of equipment and materials for the production of parts, typically utilising group technology and computer-aided manufacturing. At their highest level of integration, a cell might form a flexible manufacturing system.

**Level 3 – Linked islands.** At the third level, some cells (islands of automation) from level 2 are connected to form linked islands or larger production systems through typically computerised information systems like JIT and MRPII.

**Level 4 – Full integration.** This level is providing linkage of the entire manufacturing function and all its interfaces through and extensive information network. At this level integration is commonly known as computer-integrated-manufacturing.

In moving from level 1 through level 4, the extent of integration increases, the size of capital investments rises, the capability and sophistication of software and hardware increases, and last but least there is a increase in skill requirements, managements systems, decision latitude, and new and advanced ways of organise work. And we argue that a heedful and joint development of both people and technology where knowledgeable holistic employees are able to utilise manufacturing systems and influence on value creation creates future competitiveness. In table 2 we have made an integration of the different levels of manufacturing systems and STS design principles.

| **STS design principle** | | **Variable** | **Level 1 Stand Alone** | **Level 2 Cells** | **Level 3 Linked Islands** | **Level 4 Full Integration** |
|---|---|---|---|---|---|---|
| P1 | Compatibility | Reward system | Individual-based | Individual- or group based | Group-based | System-based |
| P2 | Min. Critical specification | | Mostly individual task design | Semi-autonomous work group design | Semi-autonomous work group design | Autonomous work group design |
| P3 | Variance control | | | | | |
| P4 | Multi-functional | Skill require-ments | High specialization | Limited multiple skill requirements | Multiple skill requirements | Low specialization, with multiple skill requirements |
| P5 | Boundary location | Structure | Rigid/ Mechanistic | Semi-organic | Organic | Organic/ networked |
| P6 | Information flow | Infor-mation | Manual | Restricted | Semi-automatic | Automatic |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | flow | exchange of information | exchange of information | transfer of information | transfer of information |
| P7 | Power an authority | Control | Bureaucratic | Semi-bureaucratic | Semi- self-regulated | Self-Regulated |
| P8 | Support congruence | Inte-gration | Limited local integration | Local integration | Semi integrated total system | Total system integration |
| P9 | Incomplete | Continuous learning | | | | |

**Table 2 STS-design principles in relation to advanced manufacturing technologies**

Table 2 will be the basis for making evaluation of both the work organisation (the social system) and the technological system. And it is as a representation of this evaluation that VSM shows its usefulness. By developing and classical VSM fact-box based on the nine design principles, represented by its chosen variable, we will be able to perform the necessary assessment of current state, actually of both the work organisation and the technological system. The VSM tool will connect the assessment to the value stream and by making and evaluation of each work group along the value stream the current state will appear.

From the Value Stream Mapping, the process map itself is one of the benefits as it allows for participation of all employees in the discussion and process of creating the map and to develop a mutual assessment of the content of the fact boxes. In such the process of creating the map is a co-generative learning process where understanding, knowledge and experience from the employees together with us as researchers are the one that completes picture and the description of the current state. Then the next step in the process will be to use the design principles as tools to both create a future state map, and to describe a suitable development process to close the gap between current state and future state.

A conceptual development of a new version of a mapping tool includes incorporating new aspects into the method. To do this focus is set on the fact-boxes of the VSM. There is a clear need to expand the contents of the topics examined, and hence, a new set of fact boxes are to be developed to help capture the full picture.

## CONCLUSION

In this paper, we argue to include work organisation aspects in western high tech manufacturing companies to stay competitive in the long run. We launch a new tool to map and develop work organisational aspects alongside technology improvement initiatives. The VSM tool is well known and well proven in industry and constitutes as a suitable tool to add new features onto. The new tool under development, the STS-VSM, will be tested in industry summer 2009.

Industry potentials, when including work organisation aspects in development processes, have several dimensions. First, building competence, focusing on the “big picture”, and paving the way for continuous improvement are necessary to stay competitive. Second, technology can be better exploited when utilised in an optimal way. And third, whilst technology easily can be copied by others, personnel competence and understanding is “company internal property”. We believe personnel skills will be an important competition

Achieving new performance levels requires that the performance is measured and informed about. What is measured is what the company focuses on. Hence, auditing work-organisation in a high-tech company is necessary.

Our approach creates some challenges;

- The audit is subjective. This might challenge the audit team in being neutral and the production area under investigation to be honest.
- The method quantifies organisational dimensions. This relies on well defined levels of performance, and that the audit personnel has training in evaluating processes
- The company must rely on that the most important issues are covered in the audit; otherwise focus will be neglected on those topics.
- The tool can hinder creativity and the ability to see improvement potentials if it gets to much attention

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