Further development of Value Stream Mapping to design work systems

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Abstract

This paper describes recent further developments of the Value Stream Mapping methodology. Those developments are enhancing and immersing Value Stream Mapping independent from the field of application. The Value Stream oriented Process Management and the joint application of Value Stream Mapping and Methods-Time Measurement (MTM) depict, how these further developments contribute to rationalisation and to continuous improvement of values streams respectively to processes and work systems. In Value Stream oriented Process Management a systematic routine to improve processes and Value Stream Mapping are integrated into the organisational framework of Process Management in order to enable a methodically fostered improvement of value streams in different levels of detail. The systematic immersion of Value Stream Mapping with MTM increases the productivity of a values stream by a coordinated design and improvement of work methods and of production-logistics aspects in work systems.

Keywords
Value Stream Mapping, MTM, continuous improvement, work systems, process language

1. Motivation und Introduction

In order to maintain and improve the competitiveness of companies (especially in high-wage countries), new ideas and attempts beside product and service innovations have to be generated, to allow and ensure an immersion and enhancement of design and rationalisation approaches in work systems design. The current ifaa-trend barometer [1] clearly supports these attempts while highlighting latest and future challenges and requirements in the fields of work organisation, Human and Industrial Engineering based on a longitudinal survey. Especially continuous improvement, process organisation and production systems as well as ergonomic work system design are of high importance for a longer period of time. Hence clear evidence/necessity and so a scientific gap arise to immerse and enhance target-oriented design and rationalisation approaches in order to plan, utilise and improve value streams, processes and works systems. In particular Value Stream Mapping turned out as an easy to apply yet effective improvement methodology. This paper presents further developments of Value Stream Mapping and focuses the necessary fundamentals subsequently.

2. Fundamentals of Value Stream Mapping

Value Stream Mapping (VSM) was originally developed as a method within the Toyota Production System [2, 3] and introduced as a distinct methodology by Rother and Shook. Value Stream Mapping is a simple, yet very effective, method to gain a holistic overview of the condition of the value streams within an organisation. Based on the analysis of the current-condition, flow-oriented target value streams (target-conditions) are planned and implemented [4-6].

A value stream includes all activities, i.e. value adding, non-value adding and supporting activities that are necessary to create a product (or to render a service) and to make it available to the customer. This includes the operational processes, the flow of material between the processes, all control and steering activities and also the flow of information [4]. In order to assess possible improvement potential, Value Stream Mapping considers, in particular, the entire operating time compared with the overall lead-time. The greater the distinction between operating and
lead-time is the higher the improvement potential [5]. By defining target-conditions, Value Stream Mapping uses a 4-Step-Method (see Figure 1) consisting of the steps “choose a product family”, “draw a current-condition map”, “develop a target-condition” and “implementation of target-condition” as well as an “action plan” to monitor the implementation, to describe necessary actions and activities (what, by whom, until when) to improve the value stream.

![4-Step-Method and the orientation towards the ideal-state](image)

The ideal-state is like a navigation point (“true north”) or like an aid to orientation for the definition or specification of the several different target-conditions for the processes [7-9]. Examples for parameters describing an ideal-state are orientation towards the customer takt, continuous one-piece-flow, 100% added value, zero-defects and lack of impairment for the workers.


Enterprises face the task of managing, designing and improving their processes in various different levels of detail – so from the main processes down to the operative work methods – on a daily base. Thus, a lot of established concepts and methods are applied practically and are depicted in literature. In most cases improvement attempts between these different levels are not linked methodically. For example, a consistent exchange of information and data between different improvement attempts does not take place.

Out of this the following questions respectively presentations of the problem are derived. How can different improvement attempts within different levels of a value stream be combined usefully? How can value streams be managed, designed and improved in a structured and repeatedly recurring way? A Process Management System in general represents a suitable approach to improve processes in the broadest sense. Out of the broad variety of concepts and methods to improve value streams, Value Stream oriented Process Management presents and combines three – broadly practically applied and theoretically well described – approaches (Process Management, Value Stream Mapping and a systematic routine to manage and improve processes). In here the mutual conjunction of volatile changes (innovation) and short-cyclic changes (continuous improvement) reflects the fundamental approach to improve value streams. Improvements to push processes to a higher performance level can be achieved by these two basic, different and theoretical principles [7].

From a process-oriented point of view there is no fundamental difference in understanding of what a “process” or what a “value stream” is. In terms of this paper a value stream is in most cases a product-oriented flow or extract of processes on a higher level of detail. A value stream may contain different processes from the Process Map or main- as well as sub- processes from “deeper” levels of detail which affect the production of a product [10]. The value stream itself consists of operative processes and the appertaining material and information flows. Subsequently a “process” describes those activities of a value stream that are necessary to create a product.

3.1 Target-conditions on routines to improve processes systematically

Short-cyclic improvement implies that processes are evolved starting from a current-condition towards a target-condition. Target-conditions (see Figure 1) can be considered as a kind of “milestone” along the way towards the ideal-state. The target-condition describes “how” a process should be performed in the near future. The development
from the current-condition to the target-condition is characterised by a lot of small, short-cyclic (univariat) improvement steps in the specific processes.

A particular target-condition is specified in detail by targets and parameters describing the process. Targets are for e.g. productivity (in terms of “performance/time unit”) or quality (“failure-free parts/total parts”). The actual- and the target-condition of the process are specified for example by parameters or indicators like cycle times (customer takt), deviation, applied work method, work in progress in the particular work system, or specifications considering the layout or organisational aspects. In order to formulate motivating target-conditions for all engaged workers, they have to be realistically attainable and demanding [11, 12]. Against this background of Rother formulated ideas and procedures of the improvement- and the coaching-kata respectively the coaching of the improvement-kata [13]. Here “Kata” describes a specified routine, a pattern or a habitual thinking and acting. These very often-repeated routines of the improvement and the coaching kata are fundamental for the systematisation of improving processes.

3.2 Process Management

Process management delimits, analyses, visualises, operates, measures, controls, documents and improves processes in order to full fill customer requirements. The Process Life Cycle (PLC) (see Figure 2) indicates and determines each stage of the life cycle of a process within a Process Management System. It starts with the incorporation of the process into the process map and it ends with the shutting down of the process. The PLC defines steps in the cycle of a process in the Process Management System in form of phases and phase transitions and is named the “large control-circuit” in Process Management. Phase 1 “Recording and Integration in the Process Map” and phase 2 “Process Definition” represent the design and conception of processes. Phase 3 “Operating, Controlling and Optimising” as well as phase 4 “Reporting and Monitoring” specify the recurring (“daily”) work of performing and improving processes.

In phase 2 of the PLC the 4-Step-Method is a vital procedure to define new processes and to change and improve already existing processes. Applying this procedure mostly results in fundamentally changed, respectively improved
The four steps are implemented by a series of – at least – four so-called Process Team Meetings (PTM). Each PTM represents a milestone during a step to ensure the systematic execution of the 4-Step-Method. The so-called Process Jour Fixe (PJF) meetings are instruments for a current and continuous control of a process in phase 3 and during the transition to reporting and monitoring in phase 4. During phase 3 – representing the so-called “daily life of a process” – the focus is set on meeting the requirements and on identifying and realising improvement actions, short-cyclic, towards a target-condition. The continuous improvement is supported by information from phase 4. The reporting and monitoring of different processes and several process goals occur in phase 4. Thus, the information available in phase 2 and phase 3 is broadened by relevant, respectively strategic parameters and aspects. All relevant information and performance indicators as well as actual problems in the daily life of the process are conditioned prior to a Process Management Review (PMR). Therefore they are also available for the PJF and the PTM in order to accomplish successful decision-making and to provide the basis for the deduction of necessary improvement actions [14].

3.3 Systematic improvement of Value Streams within the Value Stream oriented Process Management

Process Management provides the organisational framework for the systematisation of Value Stream Mapping. This is based on embedding and integrating a values stream into phases 2 to 4 of the PLC. This conjunction of continuous improvement and innovation can be found in the Process Management System, in phase 2 and 3 of the PLC and enhances the 4-Step-Method (see Figure 3).

The determination of target-conditions, (during phases 2 to 3 utilising information from phase 4), endorses the PLC by setting clearly defined intermediate goals along the way to the ideal-state (“true north”).

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**Figure 3: Enhanced 4-Step-Method of the Value Stream oriented Process Management [10]**

The determination of target-conditions, (during phases 2 to 3 utilising information from phase 4), endorses the PLC by setting clearly defined intermediate goals along the way to the ideal-state (“true north”).
Referring to the level of the value stream in phase 2, where the two 4-Step-Methods in Process Management or Value Stream Mapping are applied, the current-condition at point in time t0 is recorded and a challenging target-condition is determined along the way to the ideal-state. This target-condition “target 1” is defined during step 3 of Process Management’s 4-Step-Method and is afterwards implemented and aspired in step 4. The implementation is accomplished by realising the improvement actions summarised in the LIP or the action plan taking economic, organisational and time-related constraints into consideration. In phase 2 of the Process Management volatile and conceptual changes occur on the level of the whole value stream. From a theoretical point of view the target-condition “target 1” of the now changed value stream is accomplished at point in time t1 at the end of step 4. This attained condition at point in time t1 becomes automatically the new current-condition at point in time t1 – independent of whether the desired level has been reached or not – for the following phase of continuous improvement (phase 3).
Subsequent stabilisation
Ideally and typically, the performance of a process respectively a value stream stabilises after reaching a new performance level. Nevertheless, a decline from this performance level is the reality. As a result it is more or less impossible to attain both a target-condition and a sustainable stabilisation at the end of phase 2.

Continuous, short-cyclic changes
The most noted and practically applied method is the PDCA (Plan-Do-Check-Act)-method [15]. The PDCA-method formalises an experimental procedure as a scientific method. Hereby the emphasis is set on a systematic verification of postulated hypotheses within the scope of univariate experiments in order to gain awareness in the case of non-verified hypotheses. Due to the complexity and variability of a system it is eminently important to establish systematic and steady elapsing procedures for improvement.
In order to establish and to maintain a short-cyclic improvement process in phase 3, it is necessary to implement a structured procedure within the business organisational structure. The short-cyclic improvement has to take place with a high frequency to implement the changes in the processes. Concerning this, the applied methodical approach of univariate experiments is therefore anchored as an integrated routine in the daily operation of the business. Due to the fact that the kata is an appropriate method of improving and coaching activities [13], this systematic routine for improving processes is introduced here as the basis for continuous improvement, and enlarges and consolidates the already applied approaches and concepts (e.g. LIP, PJF, PMR) in phase 3 of the PLC. The coaching routine aims to guide and to enhance the particular workers in applying the improvement routine (PDCA-cycles). Hereeto the person has to be asked/guided/encouraged repeatedly to identify obstacles within the borders of the process and has to remove them by univariate PDCA cycles (rapid PDCA’s) instead of trying to search for solutions at the processes’ interfaces, or outside of the process as it is common practice. This “new“ behavior is a necessity to establish a continuous improvement procedure for the processes of a value stream. The value streams “target n“ and the ideal-state are aligning all the individual improvement activities. On the one hand the accompanying coaching ensures the compliance of the prescribed work methods in the work systems by different workers, and on the other hand it ensures that all possible actions for improvement within a process are actually taken into consideration.

Renewed volatile changes
A long lasting continuous improvement usually leads to diminishing changing steps. Despite the coaching procedure and all the improvement endeavours it may occur that the target-conditions cannot be accomplished within the scope of the process borders. In other words the value streams current-condition “current n“ at point in time tn does not correspond to the target-condition “target n“ (see Figure 4). On the one hand this may be a reason for determining a too short a time frame for accomplishing “target n“. In this case the frame may be extended and the improvement efforts in phase 3 within the process borders will continue. On the other hand in particular the non-attainment of the target-condition in phase 3 mainly occurs if the major, still existing, obstacle cannot be found between the processes or if it is beyond scope of action of the shift leaders. Hence it is imperative to initiate another innovation leap in order to improve the value stream in phase 2 across its process borders and to determine a new, challenging target-condition “target n+1“ at point in time tn+1. The perception for another innovation leap is supported by information from the PJF and PMR meetings as well as from the insights from the higher coaching routine.

Ongoing Monitoring
Phase 4 of the PLC is crucial for the development of a value stream – no matter if there are small steps or innovation leaps. The actual performance data of the value streams and current information concerning the organisation (e.g. key performance indicators) and the external influences are collected for the PMR. In this way the information is available for the PTM and PJF as well. Process Management Reviews help to make the performance level of value streams assessable and controllable. They provide the basis to decide if a re-design of a value stream is necessary and to set certain targets for the improvement projects. This swinging back and forth between different conditions of a PLC also represents the connection between volatile changes and continuous improvement steps.
Summarising the short-cyclic improvement routine ensures the continuous improvement of processes towards an ideal-stat by defining and achieving several target-states. The integration of this short-cyclic improvement is recommended in phase 3 of the PLC, because it improves processes target-oriented.
Following this systematic broadening subsequently a systematic deepening of Value Stream Mapping is introduced.
4. Value Stream Mapping and Methods-Time Measurement (MTM)

The combined application of Value Stream Mapping and MTM is keen on increasing productivity and therefore to raise the added value of a company. Additional goals are the reduction of lead time and therefore of inventory accomplished by Value Stream Mapping and the standardisation of processes and a well-grounded time determination based on an international performance level – the so-called “Urmeter for human work” – accomplished by MTM.

4.1 MTM at a glance

MTM is the abbreviation for Methods-Time Measurement, meaning that the time required to execute a particular activity depends on the method performed for this activity. It is a modern instrument to describe, structure, design and plan work systems by means of defined process building blocks. MTM exhibits an internationally valid performance standard for manual tasks.

A process building block represents a process step with a defined work content and a distinct purpose for which a standard time applies. A system of process building blocks consists of a defined amount of process building blocks. A MTM system of process building blocks as developed for a specific, clearly defined process typology, a specific complexity of processes and defined process characteristics [16]. MTM process building block systems are assigned to clearly defined fields of application such as, for example, mass production, batch production or job shop production. MTM process building block systems provide a formal descriptive language for processes, are used uniformly throughout the world and are keen on recognising the relevant influencing factors in a process. The use of MTM provides a valid base for the evaluation of productivity, time based information to plan and control processes and supports the identification of deficiencies within the organisation.

4.2 Joint application of Value Stream Mapping and MTM

In the context of the joint application of Value Stream Mapping and MTM the different dimensions of productivity (work method, performance, utilisation) provide a valuable and profound understanding of productivity whereas the work method plays the most important role to increase productivity [17-19].

The benefits of this joint application arise from a coordinated design and improvement of work design and production-logistic aspects in work systems, their work methods and in the overall value stream. From an Lean Management point of view both approaches are contributing to identifying, to assessing, to reducing, to eliminating and/or to avoiding waste.
Table 1: Benefits of the joint application of Value Stream Mapping (VSM) and MTM [20]

<table>
<thead>
<tr>
<th>Benefit</th>
<th>VSM</th>
<th>MTM</th>
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<tbody>
<tr>
<td><strong>Exact determination and assessment</strong> of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• operating, transport and set-up times</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>• performance and utilisation</td>
<td></td>
<td>X</td>
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<tr>
<td><strong>Reduction of lead time</strong> through</td>
<td></td>
<td></td>
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<tr>
<td>• minimising and eliminating idle times</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• improvement and redesign of methods and reducing in operating and transport times</td>
<td></td>
<td></td>
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<tr>
<td><strong>Increase in productivity</strong> through</td>
<td></td>
<td></td>
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<tr>
<td>• design of methods</td>
<td>X</td>
<td></td>
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<tr>
<td>- flow-oriented consideration (overall processes)</td>
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<tr>
<td>- task-oriented consideration (single processes)</td>
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<tr>
<td>• improvement in performance and utilisation</td>
<td></td>
<td>X</td>
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<tr>
<td>• standardising processes</td>
<td>X</td>
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<tr>
<td><strong>Reduction of inventory in form</strong> of</td>
<td></td>
<td></td>
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<tr>
<td>• raw materials, work in progress and finished goods</td>
<td>X</td>
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<tr>
<td><strong>Improvement in delivery reliability</strong> through</td>
<td></td>
<td>X</td>
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<tr>
<td>• reduction of lead time</td>
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<tr>
<td>• reduction of batch sizes</td>
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<tr>
<td>• smoothing out fluctuations</td>
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<tr>
<td><strong>Evaluation and planning of flow of material</strong></td>
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<tr>
<td>• based on standardised logistics process building blocs</td>
<td></td>
<td>X</td>
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<tr>
<td><strong>Reduction in control overhead</strong> through</td>
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<td></td>
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<tr>
<td>• simplification of information flow</td>
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<tr>
<td>- application of the principles of self-regulation (supermarket,...)</td>
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<tr>
<td><strong>Reduction in required shop floor areas</strong> through</td>
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<tr>
<td>• material flow optimisation improved workplace layout</td>
<td>X</td>
<td></td>
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<tr>
<td>• improved workplace design</td>
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<td>X</td>
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<tr>
<td>• lower stock quantities (inventory)</td>
<td>X</td>
<td></td>
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<tr>
<td><strong>Comparability and evaluation of current and target-conditions</strong></td>
<td></td>
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<tr>
<td>• internationally applied, standard performance benchmarks for human work</td>
<td></td>
<td>X</td>
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<tr>
<td><strong>Simulation capability</strong></td>
<td></td>
<td></td>
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<tr>
<td>• planning, design, assessment and optimisation of &quot;virtual&quot; methods (flow- and task-oriented) in current and target-conditions</td>
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<td>X</td>
</tr>
<tr>
<td><strong>Comprehensible documentation of methods</strong></td>
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<tr>
<td>• simple and easily understood documentation of the processes and work procedures</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>• transferability of results</td>
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Value Stream Mapping does not just contribute to reducing lead times by reducing and avoiding waste, it also contributes to increasing effectiveness and efficiency by improving work methods and the organisation of work, thereby raising productivity. In addition it provides a quick overview about the whole value stream from the supplier to the customer and focuses on the alignment and combination of individual processes and the reduction of lead time.

MTM is a tool based on a uniform process language to describe and standardise processes. In addition it provides the time (basic time) of the single processes in the value stream. Through its well-grounded time determination and with its systematic analysis of processes, MTM contributes to evaluation and productivity improvement. The focus of optimisation are the individual activities and workplaces (consideration of single processes).

Figure 5 shows how MTM process buildings blocks provide several different information to a value stream; i.e. the operating time (basic time; \( t_{g} \)), detailed, chronological description of the work method, the amount of added value respectively the amount of identifiable waste. MTM process building blocks therefore improve quality in evaluating the flow degree (lead time/operating time).
Once MTM has been successfully deployed in an organisation, Value Stream Mapping is a valuable extension in order to analyse the whole process chain. Conversely, if an organisation already uses Value Stream Mapping as a tool, the application of MTM is a useful addition. The following practical areas of application and possibilities for use result from the interplay of the combination of Value Stream Mapping and MTM (see Figure 6):

- assessment of added value rates
- assessment of production-logistics processes
- ergonomic assessment of work systems
- current/target-condition comparisons
- balancing
- layout design (overall and single level)

### Figure 5: Principle of application of Value Stream Mapping and MTM

Figure 6 visualises where MTM can be applied in a value stream.

### Figure 6: Options to apply MTM in a value stream

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- layout design (overall and single level)
5. Conclusion and Outlook

On the one hand these explanations show, how practical approaches resp. concepts applied in industry (Process Management, Value Stream Mapping, short-cyclic improvement routine) are combined in the model of Value Stream oriented Process Management in order to manage and improve processes and value streams.

On the other hand taking the aspects of reducing inventory, minimising lead times as well as the premise of increasing productivity based on a well-grounded design of work systems and work methods into consideration the joint application of Value Stream Mapping and MTM offers useful synergies. Thus, the productivity of the entire value stream – in the overall flow and in work methods – is increased and logistical, ergonomic and time data management-related aspects are considered in designing work systems.

The gathered positive experiences with these enhancements and immersions of Value Stream Mapping and the realised rationalisations lead to further developments like a procedure to comprehensively evaluate alternative value streams and a procedure to map cost developments in existing value streams depending to changing input parameters.

References