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Poster Session

Enhancing Work System Design and Improvement by Further Developments of Value Stream Mapping

P. Kuhlang[1,2], T. Edtmayr[2], A. Sunk[2], T. Mühlbradt[1]
[1] MTM-Institute, German MTM-Association, Zeuthen, Germany
[2] Institute of Management Science, Vienna University of Technology, Vienna, Austria
(peter.kuhlang@dmtm.com)

Abstract - **The main goal of a company is to conduct target oriented rationalization efforts. Thus, the challenges are, among others, to transparence, to bundle, to adapt, to re-interpret and to develop personal and organizational competencies for systematic and methodic planning, designing and implementing, i.e. giving sustainable improvement of processes and value streams. This article describes the further developments of "Value Stream Mapping" (Value Stream oriented Process Management, Value Stream Mapping and MTM, evaluation of alternative value streams, cost development of value streams by changing input parameters). Existing, implicit knowledge will be explicated and systematically bundled along the value stream from different departments of a company in order to enhance work system design and improvement. The personal and organizational system and method competencies are therefore available to evaluate improvement measures and to perform their target-oriented implementation.**

Keywords - **Competencies, continuous improvement, MTM, productivity improvement, Value Stream Mapping, work system design**

I. INTRODUCTION

Numerous (manufacturing) companies were able to increase their productivity in the last 10-15 years, enabled by continuous improvement attempts as well as by applying lean methods. Nevertheless, improvement success rates are decreasing while utilizing these methods for longer periods of time. This diminishing gradient is mainly caused by a more and more difficult and expensive identification and elimination of inefficiencies and waste. Therefore, new ideas and attempts beside product and service innovations have to be generated to allow and ensure extensions and immersions of design and rationalization approaches in work system design. By concentrating and coordinating these efforts, new requirements arise for improving value streams, processes and work systems.

Thus, these challenges for organizations derive on the one hand from revealing existing competencies for systematically and methodically planning, target-oriented design, implementation, rationalization and sustainable improvement of value streams, processes and work systems, and on the other hand from further pooling, interpreting, adapting and developing these competencies. By applying systematic approaches and by concentrating these already existing, but decentralized personal and organizational competencies, they can be utilized for evaluating improvement measures and for supporting their target-oriented implementation.

In recent years Value Stream Mapping, in particular, turned out as an easy to apply yet effective improvement methodology.

II. FUNDAMENTALS AND STATE OF THE ART

A. Definition of 'competence'

'Competence' in this paper means that individuals are characterized by competencies, and therefore they are able to organize and apply their abilities, skills and knowledge in combination with experiences, values and norms successfully in known and unknown (hence open-ended) situations. Competencies are abilities of individuals – as a consequence of organizations too – to act in a self-organized and creative manner in new situations [1]. This disposition for self-organization is one of the main preconditions while performing target-oriented planning, design, implementation and continuous improvement of value streams and socio-technical work systems in order to establish productive (efficient/effective) thus economic production/manufacturing processes, i.e. industrial (stable, deviation-resistant) value streams. They are again the premises for enabling efficient use of resources as well as ensuring the performance of manufacturing companies [2]. The personal and organizational system and methods competencies are contributing significantly to the self-organization disposition of companies and are for this reason described subsequently.

System competence represents the integral understanding of overall flows and individual performance on a systems' level, in order to guarantee a target-oriented alignment and prioritization of activities. In other words, system competence connects the close to reality understanding of overall flows with the capturing and evaluation of deviation in processes, e.g. in production/manufacturing or logistics processes, and deduces conclusive fields of actions. It also identifies targets and target-conditions from the superordinate objectives (strategic objectives, customer goals, factory goals, etc.) of the organization [3].

Methods competence refers to the application and the understanding of several methodologies, e.g. in Lean Management and Industrial Engineering. Knowing methodologies and tools, as well as being able to apply them is essential for developing a holistic understanding

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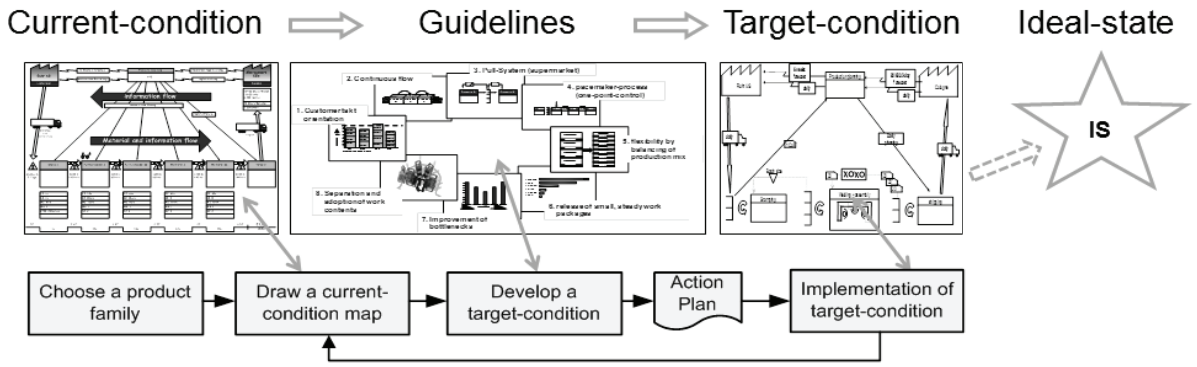

Fig. 1. 4-Step-Method and the orientation towards the ideal-state

of work system design, as well as for defining target-conditions and problem solving. Methods competence also includes the ability to select and apply suitable methodologies and tools [3].

B. Value Stream Mapping

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.

By defining target-conditions, Value Stream Mapping uses a 4-Step-Method (see Fig. 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.

The ideal-state is like a navigation point ('true north') or like an aid the orientation for the definition or specification of the several different target-conditions for the processes [5, 6]. It is represented by characteristics like (a) customer takt, (b) 100% added value, (c) continuous one-piece-flow, (d) zero defects and (e) lack of impairment for employees. Target-conditions (Fig. 1) can be considered as a kind of 'milestone' along the way towards the ideal-state.

C. 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) 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.

III. VALUE STREAM ORIENTED PROCESS MANAGEMENT

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. 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, various problems present themselves and the following questions consequently arise. 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?

Process Management provides the organizational framework for the systematization of Value Stream Mapping. This is based on embedding and integrating a value 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 (Fig. 2).

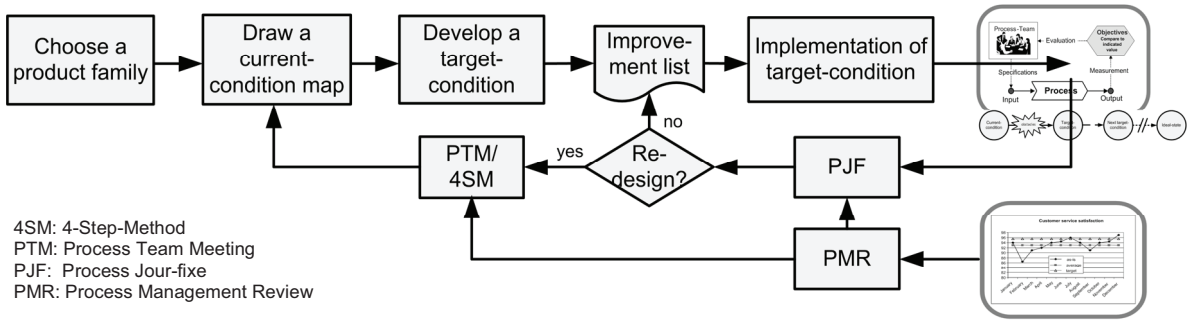

Fig. 2. Enhanced 4-Step-Method of the Value Stream oriented Process Management [7]

The determination of target-conditions, (during phases 2 to 3 utilizing information from phase 4), endorses the PLC by setting clearly defined intermediate goals along the way to the ideal-state ('true north'). Summarizing, the systematic improvement of a particular value stream is realized by its embedding into the phases of the PLC; reflecting an interplay of volatile changes, stabilizations and continuous improvements complemented by an ongoing monitoring [7].

IV. 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 standardization of processes and a well-grounded time determination based on an international performance level – the so-called 'Urmeter for human work' – accomplished by MTM. 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.

The benefits of this joint application arise from a coordinated design and improvement of work design and production-logistics aspects in work systems, their work methods and in the overall value stream. From a Lean Management point of view both approaches are contributing to identifying, assessing, reducing, eliminating and/or avoiding waste.

Fig. 3 visualizes where MTM may be applied in a value stream.

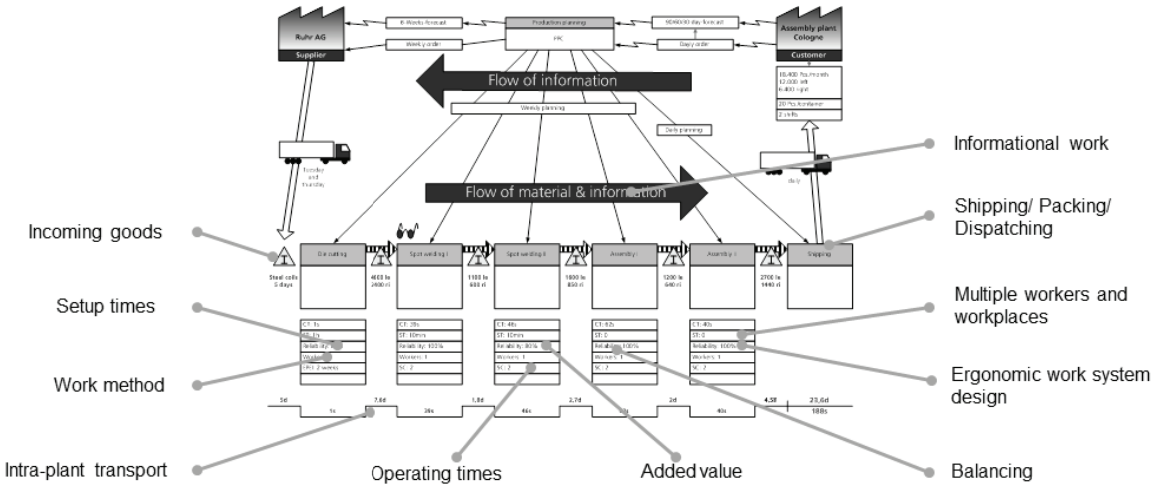

Fig. 3. Options to apply MTM in a value stream [8]

The following practical areas of application and possibilities for use result from the interplay of the combination of Value Stream Mapping and MTM (Fig. 3):

- 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).

V. APPROACH TO EVALUATE ALTERNATIVE VALUE STREAMS COMPREHENSIVELY

During the last years – as already mentioned – Value Stream Mapping was established as an approach to improve value streams, i.e. processes. Since lead time is often considered as a sole performance criterion, difficulties arise with Value Stream Mapping in selecting a unique variant out of alternative, i.e different value streams (target-conditions). Subsequent cost calculations can only provide limited predictions about a best-case solution. In the light of these shortcomings, an approach is introduced that evaluates alternative value streams comprehensively in terms of costs and benefits. This evaluation considers both the material and the information flow of a company.

This approach evaluates alternative target-conditions and the derived improvement measures based on process-oriented performance indicators such as lead time, flow degree, flexibility indicator (EPEI - Every Part Every Interval, which describes the overall time in which all product variants can be produced by one defined resource), machinery indicators (e.g., OEE – Overall Equipment Effectiveness, which evaluates the effectiveness of a manufacturing operation) and indicators of the site layout – e.g., space in m2 - as well as on economic indicators such as savings and expenses, investments and incomes, payback times and process costs.

The evaluation is carried out iteratively with an increasing level of detail. The calculation of a 'value stream assessment factor', based on the defined ideal-state (= highest monetary and non-monetary benefit) is made, as well as coupling of the two overall benefits in terms of indifference curves (see Fig. 4). This visualization of the results shows the position of the different alternative target-conditions, both in relation to each other and in relation to the current value stream and also in relation to the best in class value stream (ideal-state). Additionally, this indifference curves shows, which alternatives have the same relationship of costs and benefits. This factor helps to find the best alternative respectively the target-condition. Finally, an implementing plan is developed after selection of the appropriate alternative (of appropriate target condition), which is based on the taken actions and contains important milestones and responsibilities [9].

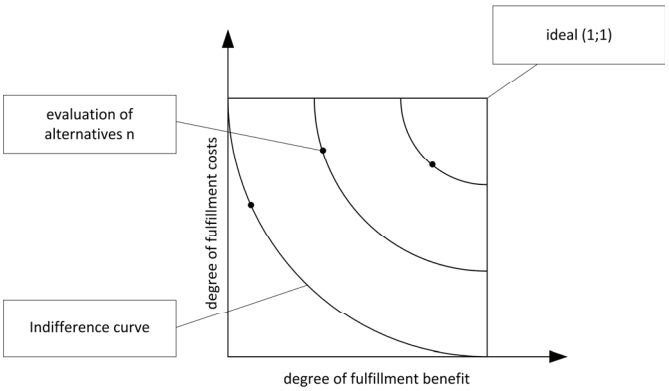

Fig. 4. Evaluation of alternative target-conditions by indifference curves [10]

VI. APPROACH FOR MAPPING COST DEVELOPMENTS IN EXISTING VALUE STREAMS DEPENDENT ON CHANGING INPUT PARAMETERS

Since different production programs lead to different overall costs, it is necessary to benchmark the effects of changes in monetary values. To evaluate value streams concerning these scenarios (future developments i.e. changes of input parameters), the mathematical relations and dependencies of all processes and stocks, as well as bottlenecks and their possible adjustments have to be determined.

The flexibility indicator Every Part Every Interval (EPEI) is thereby the fundamental link between production program and costs within the value stream. On the basis of bottleneck-determination through EPEI and lot sizes, development of costs in value stream are mapped in changed scenarios i.e. production program.

To determine the different costs (cost-types) and cost drivers in the value stream, expenses are linked through assets, salaries and running costs such as energy and operating costs, set-up, storage, handling, space costs from the buffers and processes with the flexibility indicator EPEI depending on variants and quantities. By connecting with a specific production program the costs for the production processes, the costs of buffers and warehouses as well as the costs in supporting areas and finally the overall costs along the value stream are calculated (see table 1).

The overall costs are calculated for various production programs representing different scenarios. After all defined scenarios have been calculated, respective results are compared with each other by presenting changes of costs at changing quantities, costs at changing variants and possible intensity adjustments or changes of lot sizes [10].

Finally, the contributions of the presented further developments of Value Stream Mapping to system and methods competence are described.

TABLE I
APPROACH FOR MAPPING THE DEVELOPMENT OF VALUE STREAM COSTS DEPENDING TO CHANGING INPUT PARAMETERS [11]

Step 1: Data capture of the current state 1. Resource- and variants specific data 2. Assets and expenses 3. Activities in supporting areas
Result: Mapping of the value stream, overall expenses current state
Step 2: Capacity leveling and possibly capacity adaption (no considerations of setup times and lot sizes)
Result: Necessary investments in capacity expansions (facilities, workers, overtime)
Step 3: Bottleneck determination by EPEI and evaluation of lot sizes
Result: $\mathrm{EPEI}_{\mathrm{Bottleneck}} = \max(\mathrm{EPEI}_{\mathrm{min1}}, \ldots\ldots, \mathrm{EPEI}_{\mathrm{minm}})$, Lot sizes as calculation basis for cost calculation
Step 4: Calculation of costs 1. in processes 2. in buffers 3. in supporting areas 4. summation value stream
Result: Overall costs of the value stream in the considered scenario ($\mathrm{GK}_{\mathrm{WS}}$)
Step 5: change of scenario →back to Step 2
Result: Input of a new production program
Step 6: Mapping of the cost development of different scenarios
Result: Change of costs by changing input parameters
Step 7: Interpretation of results
Result: Impact of the production program on EPEI on lot sizes on costs

VII. CONTRIBUTIONS OF FURTHER DEVELOPMENTS TO SYSTEM AND METHODS COMPETENCE

An important consideration to enhance system and methods competencies can be found in the fact that known and proven methods from a variety of disciplines and areas of a company have to be brought together. Thus, implicit personal and organizational knowledge of the acting employees is made available and the cognitive capability of a social entity (collective intelligence) is increased. By concentrating competencies systematically along the value stream, they are available to support rationalization attempts in an appropriate application-oriented way. System and methods competence are addressed through the model of Value Stream oriented Process Management by imbedding Value Stream Mapping and a short-cyclic improvement routine into the organizational framework of Process Management to support a systematic improvement of value streams in different observation levels and degrees of details methodically. Similarly, these competencies are enhanced by a systematic immersion of the Value Stream Mapping with MTM, since a coordinated design and an improvement of work design and (production) logistical aspects in work systems and their work methods as well as along an entire value stream takes place. The system competence for the purpose of deflection of targets or target-condition from higher-levelled target-systems and the associated prioritization of targets and measures addresses the procedure of alternative value streams especially. Similarly, the methods competence is enriched by numerous methodical improvements, e.g., definition of target-condition and determination of economic figures. The need for comprehensive determination of costs of existing value streams contributes significantly to the expansion of the system and methods competence of companies.

VIII. SUMMARY AND OUTLOOK

On the one hand these explanations show how practical approaches, i.e. rationalization concepts, are applied in industry (Process Management, Value Stream Mapping, short-cyclic improvement routine, MTM) are combined in order to manage and improve processes and value streams. On the other hand, these considerations demonstrate that the approaches to evaluate value streams offer comprehensive analysis and evaluation approaches to secure strategic planning processes.

The introduced systematic and methodical extensions and immersions prove the comprehensive and generally accepted further developments of the Value Stream Mapping. They also expand the portfolio of available lean methods to support rationalization attempts and work system design and improvement methodically. The further developments of Value Stream Mapping focus on the entire flow and on details, thus creating synergies for designing and improving value streams, processes and work systems. Due to these further developments, decentralized existing implicit knowledge is made explicit in different areas of a company. Further, known and proven methodologies from different disciplines and areas of a company are brought together and bundled along the value stream.

Thus, the personal and organizational system and methods competencies are available to evaluate improvement procedures and support their target-oriented implementation. The collective intelligence of a company enhances, since these competencies are made transparent, combined, adapted, reinterpreted and further developed. Therefore, systematic and methodical planning, target-oriented design, implementation and rationalization as well as sustainable improvement of processes, i.e. value streams, are enabled.

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