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HYBRID OPTIMISATION OF ADDED VALUE WITH VALUE STREAM MAPPING AND METHODS-TIME MEASUREMENT

This paper is about a new methodical approach of the joint and simultaneous application of Value Stream Mapping and Methods-Time Measurement (MTM). The focus of Value Stream Mapping is the alignment and combination of individual processes to form a continuous, efficient value stream through the organisation (macro consideration). MTM provide an exact determination of times and focuses on executions of individual tasks and working places (micro consideration). A hybrid optimisation of added value originates from the reasonable and useful combination of Value Stream Mapping and Methods-Time Measurement for increasing productivity, reducing lead time and exact determination of times.

1. INTRODUCTION

Increase of productivity, reduction of lead time and cost savings are permanent targets and challenges for companies. Thus activities of optimisation became part of day-to-day business in many enterprise of all kind of industries. To guarantee sustainable and efficient improvements, selective measures are not adequate, but a methodical approach for a holistic optimisation of the added value system is required. This applies both to the production of industrial goods and the provision of services including all direct and indirect processes which are necessary for the realisation of the added value.

Numerous tools and principles to cope with this task can be found in Lean Management concepts. One approved tool of the Lean kit is Value Stream Mapping (VSM), which examines the whole process chain and puts emphasis on the reduction of lead time and inventory by eliminating waste. Another well proven tool for structuring, designing and planning of processes is Methods-Times Measurement (MTM). By using clearly defined process elements, the instrument enables an exact determination of times and focuses on the execution of individual tasks and working places.

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2. VALUE STREAM MAPPING

The concept of value stream includes all activities, i.e. value-adding, supporting activities and waste, that are necessary to create a product (or to render a service) and to make it available to the customer. These comprise not just the operational processes and the flow of materials between processes but also those activities with which processes and the flow of materials are controlled, including all information flows required for this. Taking a value stream view means considering the general picture of an organisation and not just individual sub-processes thereof. Value stream mapping was originally developed as method of Toyota's production system and is an essential component of lean management. It was first introduced as an independent methodology by Mike Rother and John Shook [7]. Today VSM is successfully employed all over the world, particularly in English- and German-speaking regions [3].

Value stream mapping is a simple yet very effective method allowing one to gain a holistic overview of the status of the value streams in an organisation and, on this basis, to plan and implement a flow-oriented value stream.

In contrast to other methods, value stream mapping does not just work with material flows but also considers and maps the flow of information. In doing so, it uses clear symbols that depict actual situations and thus facilitate or even make possible the communication within the organisation about the causes of problems. VSM provides a very fast overview of the whole value stream from the supplier to the customer, with the focus lying on lead time and linking processes. The methodology aims especially at reducing or eliminating waste along the value stream in terms of lean management.

In order to assess possible improvement potential value stream mapping considers in particular a product's entire operating time compared with the overall lead time. The greater the discrepancy between operating and lead time the higher the improvement potential [3].

In a typical value stream mapping project products are first segmented and a family of products is selected for optimisation. Value stream analysis then follows, during which all relevant data of the current state are gathered in order to obtain an overview of current material and information flows. Using this as a base, the actual value stream design can then be performed by generating a possible future target state. For this specific guidelines are employed based on established lean principles. As soon as a common perception of the target state is reached measures can be defined and their implementation can begin. An example of this could be the amalgamation of separate workplaces into a flexible, one-piece flow assembly cell.

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 and thereby to raising productivity. In fact, the focus of optimisation is the alignment and combination of individual processes to form a continuous, efficient value stream through the organisation (macro consideration).

3. METHODS-TIMES MEASUREMENT

The sense and necessity of a granular consideration of complex work processes is based on the recognition of time and cost drivers. The use of standard times for elementary work steps, so-called standard procedures, and the acknowledgement of their relevant influencing factors allow design and optimisation plans for work systems to be created interactively with the required work processes [2].

MTM is the abbreviation for Methods-Time Measurement, meaning that the time required to execute a particular job depends on the method selected for the activity. MTM 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. MTM is a process that breaks down a motion-sequence in its basic motions. Each basic motion relates to a standard motion time whose rate is (pre-) determined by the influencing factors. It is used where performance-oriented human work must be planned, organized, and executed. MTM does not apply to creative tasks, but it applies to informational and mental tasks. MTM applications can be found in production, logistics and maintenance, as well as in the administration and service sectors [2].

Today, MTM is the most popular method of predetermined times in the world, thus establishing a worldwide uniform standard of planning and performance for globally active businesses.

A process building block is a process step with defined work content and a distinct purpose for which a standard time applies. A system of process building blocks consists of a delimited amount of process building blocks. An MTM process building block system [2] is developed for a specific, clearly defined process typology, a specific complexity of processes and defined process characteristics. These systems are assigned to clearly defined fields of application such as for example mass production, serial production or job shop production. The most important process building block systems are the basic MTM-1 system and the more condensed UAS (Universal Analysis System) and MEK (MTM in job and small batch production). MTM process building block systems provide a formal descriptive language for processes, are used uniformly internationally and train the eye to recognise for relevant influencing factors in a process.

The use of MTM process building block systems aids the definition of productivity characteristics and of time based planning and control information and the identification of deficits in design and organisation. With its well-grounded time determination MTM contributes a base for evaluating productivity and with its systematic analysis by means of a process language a basis for productivity improvement. In fact, the focus of optimisation are the individual tasks and working places (micro consideration).

4. BASIC CONSIDERATION OF THE EFFECT OF VALUE STREAM MAPPING AND MTM ON INCREASING PRODUCTIVITY

The focus of attention when deploying both MTM and value stream mapping is to increase productivity. Further objectives are the reduction of lead time for value stream analysis and accurate time determination on the basis of an international performance standard for MTM.

4.1. LEAD TIME

Viewed at a high level of abstraction the lead time is that period of time (hours, minutes,...) required by any process to transform the inputs (materials, customers, money, information) into outputs (goods, services). A precondition for determining lead time is the specification of measuring points. In a work system or chain of processes an idle time following processing and transport is allocated to the subsequent workplace or subsequent process. The five elements of idle time before processing, transport, idle time after processing, set-up and processing determine the lead time of a process [1].

According to Little's Law the extent of inventory reveals a lot about the lead time. This extent of inventory more or less corresponds to the idle and/or transport times. In general terms, the idle time thus consists of operating and process times and idle, transport and set-up times.

A value stream's lead time results from the sum of all operating, process and set-up times of the processes as well as the extent of the various inventories [3].

$$LT = \sum_i (OT + PT + ST) + \sum_j IR = \sum_i (OT + PT + ST) + \sum_j (IT + TT)$$

LT	…lead time (of a specific value stream)	IR	…inventory range
OT	…operating (processing) time	i	…no of processes
PT	…process time	j	…no. of different “work in progress”
ST	…set-up time		
IT	…idle time		
TT	…transport time		

4.2. PRODUCTIVITY

Productivity is the expression of the quantitative productiveness of an economic activity (of the product realisation process) and allows conclusions to be drawn as to how well the factors deployed are used. In the case of productivity output is proportional to the input factors (Productivity = Output/Input) [6]. The assessment of the efficiency of a process is performed using the figure of "productivity" ("Is work being performed correctly").

However, it does not just depend on doing something correctly (efficiency in the sense of "doing things right"). What is also essential is doing what is correct (effectiveness in the sense of "doing the right things") [5].

Measuring productivity plays an important role in engaging with productivity improvements as without measurement there is no reference base for comparisons and it is therefore not possible to judge whether a measure or idea for improvement is good or bad. Measuring the productivity of equipment is relatively simple as machines have a maximum capacity that should be exploited. Measuring or assessing the productivity of human performance is less straightforward ("What rate of performance does a person supply?").

On the one hand, raising productivity is based on measurement (for example by calculating the output/input ratio) and on the other hand on the effective and efficient design of processes. For this, a closer consideration of the influencing factors on productivity is of great importance. The factors of method, capacity utilisation and performance influence productivity for human and for machine resources [4]. A consideration of the different aspects of productivity provides a profound understanding of this relationship and a basis for measures to increase productivity. The characteristics of the factors describe and influence the type, the execution, the design and the modification of a process.

5. DIMENSIONS OF PRODUCTIVITY

5.1. METHOD

A (work) method describes the actions assumed to be necessary in order to accomplish a (work) assignment [2]. In this context a method can be interpreted as a broad concept that can apply to work methods in the whole process chain, individual processes or tasks. The method describes "how" a work assignment or work content in a specified work system is fulfilled.

The design of methods is the most important dimension for influencing productivity. Planning and implementing "well" designed, i.e. efficient and effective methods are at the focus of measures to increase productivity. A method also affects the other two dimensions. For example, capacity utilisation is influenced by better coordination of workplaces or by a reduction of hold-ups and performance for example by the motivation and training of staff. It is therefore of fundamental importance when undertaking measures to raise productivity to start with the design of methods [4], [8]. The design areas of methods are broken down into the categories “macro”, “micro” and “information and control”.

5.2. PERFORMANCE

The performance dimension considers aspects of performance level. The question of "How much was produced or can be produced in the time worked?" is at the core of considerations about how to increase productivity. Aspects such as performance standards (performance rate, actual/target-time ratio), training, motivation and targets are areas of design for this dimension.

5.3. UTILISATION

The dimension of utilisation considers aspects of the degree to which resources are utilised. The question of "How much was worked or can be worked?" is at the core of considerations about how to increase productivity. Aspects such as net time worked, attendance time, orders filled, cycle coordination, set-up procedures, inventory reductions are areas of design for this dimension.

The following Table (see Tab.1) provides an overview of the different design areas for the dimensions method, performance and utilisation.

Table 1. Dimensions of Productivity

Method	Performance	Utilisation
Macro (flow-orientated view) • process organisation • production systems • layout - workplace alignment layout (factory, floor, assembly line, cell…) • material flow • product design **Micro (execution-orientated view)** • layout - workplace design (tools, fixtures, machines…) • added value, complimentary work, waste • handling expenditures • expenditures for controlling and supervision • ease of assembly/disassembly • ease of grasp/operability • manual material handling **Information flow und control** • Production planning and controlling	• performance standards (performance rate, actual / target-time ratio, standard time, norm performance, …) • labor standards • training, routine • motivation • target orientation / monitoring • competences, skills, education • support / instructions, coaching • speed of machines	• man-hours net work, total amount of hours avaliable • Balancing (static, dynamic) • work in progress / inventory • stock • idle times • quality • setup times / change over efficiency • maintenance • machine utilisation

6. JOINT APPLICATION OF VALUE STREAM MAPPING AND MTM

When designing the method, value stream mapping is used at the macro level and information and control flow as well as MTM is used at the micro level. MTM serves to correctly determine and assess the performance level. Capacity utilisation is influenced by both MTM and value stream mapping. The two tools complement each other perfectly in contributing to raising productivity as the combined application of value stream mapping and MTM affects the design of all three dimensions of productivity (see Fig. 1).

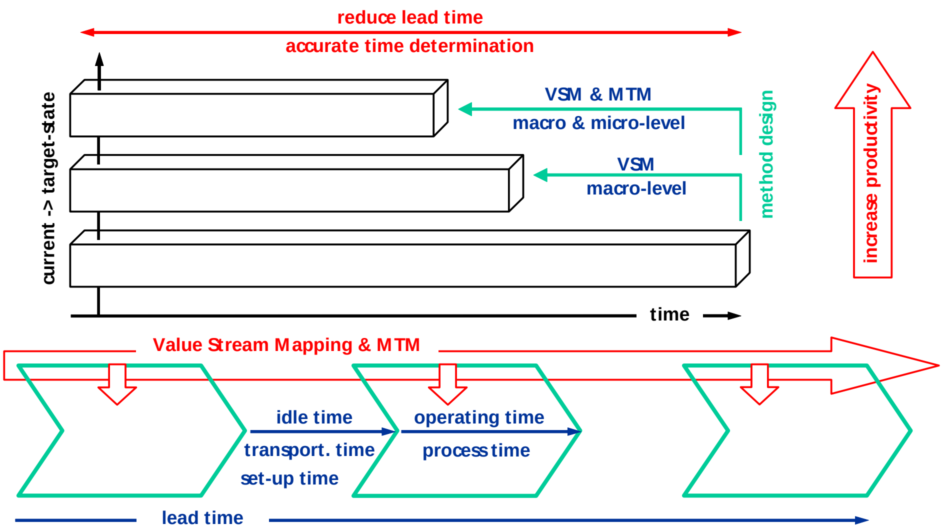

Fig. 1. Lead time reduction with VSM and MTM

The interaction of value stream mapping and MTM at different levels of detail consideration contributes to the identification, elimination and avoidance of waste and thus to the design of efficient and effective processes. The mutual benefit of the combined application arises from the increase in productivity, from the reduction in lead time and from the accurately determined times.

The following Table (see Tab. 3) provides an overview of the most important benefits from the joint application of value stream mapping and MTM.

Table. 3. Benefits of the combined application of value stream mapping and MTM

	VSM	MTM
Accurate determination and assessment of • operating, transport and set-up times • performance and utilisation		 X X
Reduction of lead time through • minimisation and elimination of **idle times** • improvement and redesign of **methods** and through this reduction in operating and transport times.	 X X	 X
Increase in productivity through • design of **methods** (increased effectiveness) ○ flow-oriented consideration (macro view) ○ task-oriented consideration (micro view) • improvement in **performance** and **utilisation** (increased efficiency)	 X	 X X
Reduction in inventory in the form of raw materials, work in progress and finished goods stock	X	
Improvement in delivery reliability through reduction of lead time, reduction of batch sizes and smoothing out of fluctuations	X	
Reduction in control overhead through simplification of information flow and	X	

application of the principles of self direction (supermarket,...)		
Reduction in required floor space through • material flow optimisation • improved workplace layout • improved workplace design • lower stock quantities (inventory)	 X X X	 X
Comparability and evaluation of current and target states • internationally applied, standard performance benchmarks for human work		X
Simulation capability • planning, design, assessment and optimisation of "virtual" methods (flow- and task-oriented) in current and for the target state.	X	X
Simple and comprehensible documentation of methods • simple and easily understandable documentation of the processes and work procedures and transferability of results	X	X

7. AREAS OF APPLICATION

Once MTM has been successfully deployed in an organisation, value stream mapping is a valuable extension in order to examine methods. Conversely, if an organisation already uses value stream mapping as a tool, the application of MTM is a useful complement as it consolidates ideas on the design of methods. In cases where neither tool has been employed, their combined use is expedient and necessary from the very beginning. Possible areas of application, e.g. time determination, assessment of added value rates, ergonomic assessment, current/target-state comparisons, balancing and layout design result from the interplay of the combination of value stream mapping and MTM.

7.1. TIME DETERMINATION

Value stream mapping is a simple tool that should rapidly deliver useful results. There is often not sufficient "time available" for time determination. In this case, the use of MTM process building block systems provides a valuable and necessary addition (see Fig. 2). The sequential description of the individual processes of a value stream using MTM process building blocks leads to detailed questions being asked, focuses attention on the relevant influencing factors of the process and results in the operating time (basic time). The description and the design of processes becomes important and the total time is calculated as a “by-product” from the MTM process building blocks.

7.2. ASSESSMENT OF ADDED VALUE RATES

The systematic identification of waste is the precondition for avoiding wasteful activities through change or improvement in the design of target processes. The use of MTM ensures the time of the waste part is assessed. A fundamental concept of lean management and continuous improvement of process (CIP) that is decisively responsible for raising productivity is the search for and identification and elimination of waste. This ensures that e.g. superfluous movement, transport, reworking and other wasteful or non-value-enhancing parts are removed from or at least minimized within the processes. It is necessary to assess the amount of waste (see Fig. 2) in order to sustainably prove the results of improvement measures. MTM process building blocks meet this requirement particularly well as every simulated or actual change to an operating procedure is immediately quantifiable in terms of time – and subsequently in terms of cost – in the form of the MTM performance norm intrinsic to every process building block [2].

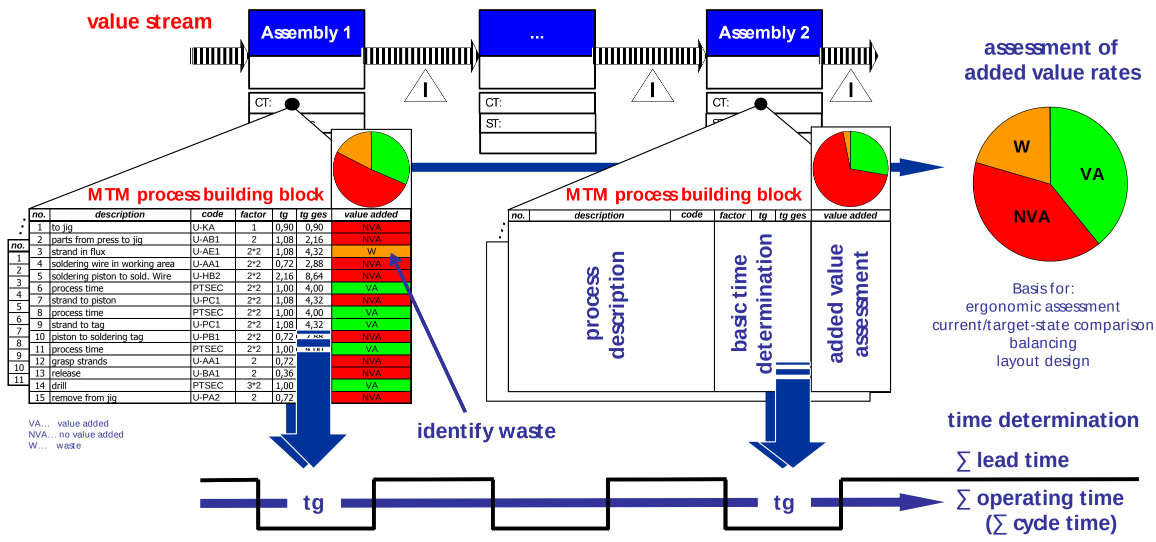

Fig. 2. Time determination and assessment of added value rates with VSM and MTM

7.3. CURRENT/TARGET-STATE COMPARISONS

The rapid deployment intrinsic to value stream mapping usually leads to less importance often being attached to the current-state. It is therefore often hardly possible to compare the planned and implemented target states. This is especially true in the current value stream for the determination of cycle times (operating times). The simple and rapid application of concentrated MTM process building block systems provides an accurate assessment of the processes of the current value stream. This creates the basis for the comparability of the target state achieved with the current state under consideration and for the assessment of realised improvement potential realised.

7.4. BALANCING

Design principles such as e.g. adapting to customer work cycles or the design of one-piece flow production present particular challenges for coordinating the cycles of workplaces and workstations. During balancing, the cycle times of serially connected work stations are coordinated with one another taking account of technical circumstances. Work content must be apportioned and aligned across the individual work stations in such a way that no substantial idle times occur at individual work stations and no staff or equipment is overloaded. Balancing equilibrium and the effectiveness of the line are used as assessment criteria [2]. Using the granularity MTM process building blocks facilitates the even distribution of work content across work stations.

7.5. LAYOUT DESIGN

The interaction of value stream mapping and MTM as tools for the design of methods at the micro and macro levels provides valuable information for the planning and design of layouts for workplace arrangement and workplace configuration.

8. SUMMARY

The method has the largest influence on productivity. Both value stream mapping and MTM are acknowledged tools for the design and optimisation of work methods. In joint application with value stream mapping, MTM clearly focuses on raising productivity and exactly determining time under the aspect of observing the execution of individual tasks (micro consideration). Through its flow-oriented view of the entire process chain (macro consideration), value stream primarily contributes to a reduction in lead times and to an increase in productivity. A hybrid optimisation of added value originates combination of Value Stream Mapping and MTM for increasing productivity, reducing lead time and exact determination of times.

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