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IMPROVING PRODUCTIVITY BY DERIVING AND DEFINING TARGET CONDITIONS IN THE VALUE STREAM OF PACKING

Summary

In the entire value stream of original spare part supply, packing is one of the main issues in the distribution system and its productivity is mainly affected by a particularly high proportion of manual work. This paper presents an approach to support practical work improvements in value streams generally, and from the theoretical and the practical point of view it shows how performance enhancing and learning enhancing target conditions or standards – e.g. for the working method – can be derived and defined from the ideal state and its characteristics in order to increase productivity. The implementation of a target condition is carried out by continuous and discontinuous improvements to the value stream of packing original spare parts.

Key words: *logistics, value stream, target condition, methods-time measurement*

1. Introduction

The after-sales service and in particular the supply of original spare parts is an important branch in the automotive industry with high growth potential in the competitive market environment, which enables an original equipment manufacturer (OEM) to generate additional revenues [16, 31, 36, 40]. Considering the total value stream of supplying original spare parts, packing is one of the most important activities in the distribution system as well as in the supply chain [4]. Packing is the moving of customer specific original spare parts out of a package (i.e. metal box, metal cage, small parts bin, heavy parts bin) into a cardboard box. In such a case, packing is done in a separated area; it starts after ordered spare parts have been picked from the warehouse and ends with cardboard boxes filled with customer ordered parts and quantities ready for delivery [10]. Several authors point out the manually intensive work processes of picking and packing, because the handling and moving of both original spare parts and cardboard boxes is difficult to standardize due to their variability and thus the process is hardly automatable [4, 17, 22, 23].

In packing, especially value added and non-value added manual activities affect productivity and must therefore be systematically planned and improved [10, 15, 23]. Caused by this effect, cost pressure for companies in high wage countries intensifies along with globalization, the challenging competitive situation and the current reindustrialization. Thus, especially for packing of original spare parts, new and stricter requirements arise for the productivity management of companies. So, the systematic application and further development of modern improvement methods and improvement procedures are necessary to meet these requirements [19]. As practice shows, the methods of Value Stream Design and Methods-Time Measurement (MTM) have proven to be suitable for achieving work improvements and consequently for increasing productivity; e.g. for identifying and reducing waste activities as well as the evaluation of indicators [8, 20]. This paper points out how the value stream of packing in the supply of original spare parts is developed to achieve an ideal state by defining performance enhancing and learning enhancing target conditions in the sense of setting a new standard for several parameters. Therefore, necessary fundamentals are described in the following subsection.

2. Fundamentals

Productivity is a measure of the production factors “workforce”, “machine” and “material”. It is represented by the ratio of performance to input. When calculating productivity, output (performance) is represented by a specific quantity, e.g. of produced goods. Input is quantified by using production factors; e.g. the figure for workforce productivity is given by the number of workers or time units [1, 7, 19, 28, 29]. Upon closer examination of the factors influencing the productivity, it becomes obvious that for human and machinery resources especially the aspects “working method design”, “level of performance provided” and “degree of utilization of resources” affect productivity [11]. In any case, working method design is the most important aspect of influencing productivity [11, 20, 35]. Manual working methods can be described and specified by the MTM method descriptions and the resulting basic time t_g and can be implemented and improved in further steps.

2.1 MTM method descriptions for designing logistic processes

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 an instrument to describe, structure, design and plan working systems by means of defined process building blocks. MTM exhibits an internationally valid performance standard for manual tasks. Hence, this well-grounded time determination based on an international performance level is often called 'Urmeter for human work' [2]. For modelling logistic processes, the application of the MTM system has a long tradition and in recent years it has also grown in importance due to increasing logistics costs. The increased costs are caused on the one hand by high technical, organizational and staffing requirements, and on the other hand, by insufficient accuracy in consideration to logistic processes. Here, the application of MTM systems – in particular the MTM Logistics – contributes significantly to the design and rationalization of logistic processes, e.g. when planning and designing logistic processes, such as picking, packing, testing, or transporting. These activities, which may show different complexity, are the so called Standard Operations Logistics [27]. Furthermore, the following frame conditions for logistic procedures have been assumed with the development of the process building blocks [26]:

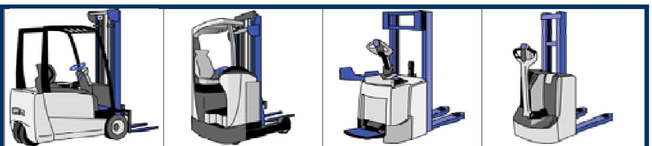
- Standard Operations are order related, with partially high repetitiveness allowing the employee to establish routines.
- Suitable working and transport means are available to the employee for the tasks.
- Working systems are designed according to the spectrum of the tasks.

These frame conditions characterize process type 2 (or: series production). For this reason, the Standard Operations Logistics is modelled by using the MTM-UAS Basic Operations [26]. In practical applications, especially the process building blocks for transport (Standard Operations of Transport) and handling (Standard Operations of Handling), e.g.

planning and designing logistic processes in automotive industry, are of considerable relevance.

The Standard Operations of Transport include all necessary building blocks for the evaluation of standard processes in commercially available and frequently used vehicles or transport carts. Here, the frame conditions, such as different driving states, relevant safety regulations and different vehicle equipment are considered for the development. Moreover, the Standard Operations of Transport include general building blocks, such as starting and stopping the engine, fastening a seat belt, and specific building blocks related to various transport means [26]. The Standard Operations of Handling are process building blocks for evaluating (manual) processes related to commercially available and frequently used transport units, including typical information or data processing activities. Standard Operations of Handling are developed for the activity groups of (a) handling, (b) opening packages, (c) closing packages and (d) processing information [26].

When planning logistic processes, the Operation Sequences of Forklifts of the MTM Logistics have proven to be particular applicable. They are a result of aggregating and statistical weighting of the Standard Operations and contain typical driving operations for lifting up and placing pallets, containers or similar transport aids with defined forklifts. By using the Operation Sequences of Forklifts, minutely detailed method descriptions of logistic processes and transport sequences can be formulated. Different transport modes, transport equipment features and operating levels can be analyzed and described accurately and adequately regarding their individual attributes [26].



Forklift Operation sequences										
Lift	Place	Time values in TMU	Driver seated forklift				Pallet truck			
			Forklift		Reach forklift		drive-along		walk-along	
		Align	Without	With	Without	With	Without	With	Without	With
		5LT	FO	FM	SO	SM	MO	MM	GO	GM
Floor	Floor	SAAA	603	833	718	983	496	696	646	971
	1.2 m	SAAB	751	981	903	1168	790	990	1002	1327
	2.5 m	SAAC	912	1142	1105	1370	1119	1319	1442	1767
	4.0 m	SAAD	1098	1328	1337	1602	1499	1699	1949	2274
1.20 m	Floor	SABA	854	934	1014	1084	782	847	1105	1210
	1.2 m	SABB		1082		1269		1131		1556
	2.5 m	SABC		1243		1471		1460		1995
	4.0 m	SABD		1429		1703		1840		2502
2.50 m	Floor	SACA	1000	1080	1160	1230	1017	1082	1407	1512
	1.2 m	SACB		1228		1415		1366		1858
	2.5 m	SACC		1389		1617		1695		2297
	4.0 m	SACD		1575		1849		2075		2804
4.0 m	Floor	SADA	1168	1248	1328	1398	1288	1353	1755	1860
	1.2 m	SADB		1396		1583		1637		2206
	2.5 m	SADC		1557		1785		1966		2645
	4.0 m	SADD		1743		2017		2346		3152

Fig. 1 Excerpt from Operation Sequences of Forklifts [26]

2.2 Relevance of standards to practical work improvements

Generally, standardizing means „unification of products (…) and components (...) as well as boundedness to rules of production and administrative processes (…)" with a documented standard as a result [3]. The regularization or standardization of operations is of great importance for (industrial) companies nowadays; i.e. in German speaking Europe lots of companies interpret standards as means for stabilizing production and logistic processes in order to keep output at a defined performance level or to harmonize sequences of processes. As a result of this understanding (Taylor's "one-best-way principle"), standards become static and should be valid for a long period of time [5]. But, this understanding inhibits a target oriented improvements to processes. The attempts known from the Toyota Production System interpret a standard in the sense of a target condition to be distinguished from a current condition clearly (see Fig. 2) [6].

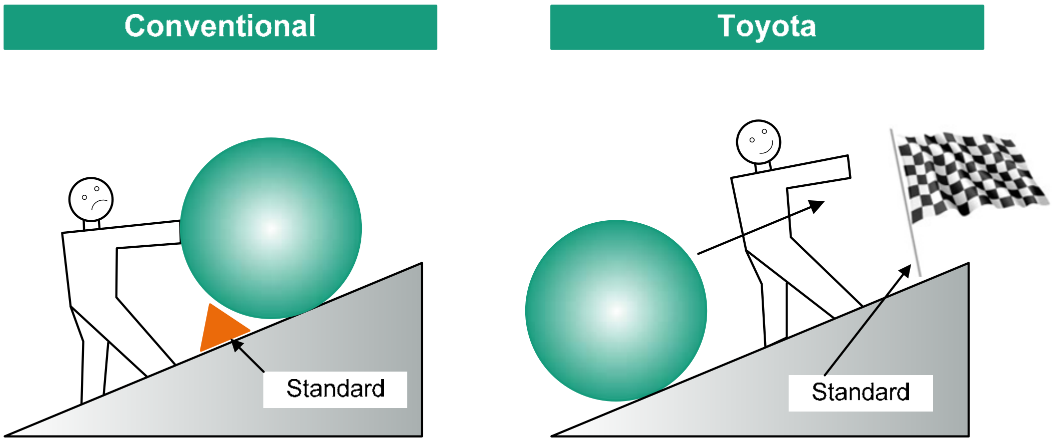


Fig. 2 Standards in conventional sense and as target condition [19]

With this distinction, a basis for target oriented process improvements is formed [33]. The reduction in discrepancies between the current condition and the standard leads to the target oriented operation and process improvements [34]. It is necessary therefore to define standards for operations for targets concerning workers, to declare the standards on-site and to describe processes for workers, production facilities and material. Departures from standards are detected and can be removed by applying improvement measures. Hence, priorities are set clearly, workers are involved directly and fast short cycled improvement steps as well as big innovation leaps are implemented and assessed. For example, a working method description defines operation sequences of processes independently from the point of view of standards. But, the description is a standard in the sense of making discrepancies between current conditions and target conditions in processes visible so they can be analyzed comprehensively as a basis for improvement measures, e.g. within a continuous improvement process [39].

Standards of operations include detailed descriptions of single motion sequences as well as their chronological sequences, which are performed by workers at the assembly or packing line or transport equipment in internal logistic processes. The result of such detailed MTM method descriptions is the allocated basic time t_g or standard time t_e. A detailed description of standards, such as the one applied by the MTM system, is the fundamental requirement and the initial state for improvement measures. Organizations have to be aware of discrepancies between current conditions and target conditions or standards in processes. They should be able to assess them, to see these departures from standards as a potential for rationalization and to make them visible in order to set accurate improvement measures [33].

2.3 Using Value Stream Mapping for practical work improvements

The paradigm of striving for an ideal state – it can be considered to be a vision – is the basis for the improvement of a value stream and its processes. The ideal state describes the condition of a value stream with zero losses so that added value is generated at minimum costs [34]. This ideal state is used as a navigation link ("true north") or orientation guide and is represented by characteristics, such as 100% added value, continuous one-piece-flow, zero defects and lack of impairment for employees [21]. The ideal state gives direction for deriving and defining several target conditions for a value stream [6, 9, 13, 21, 37].

According to Toyota's point of view, the next target condition to be accomplished when striving for the ideal state can be interpreted as a new standard [19]. Hempen describes a modern approach to defining target conditions, which is a difficult issue in practice. Here, target conditions are defined by parameters which are categorized as follows: (C1) calculated indicators, (C2) general process information, (C3) process pattern and process indicator and (C4) performance indicator. Typical examples of these categories are customer takt time as a calculated indicator, defined inventory size as general process information, working method as process pattern, basic time as process indicator, and productivity as performance indicator [12]. The parameters for specifying and defining target conditions are based on performance enhancing and learning enhancing target setting characteristics. On the one hand, performance enhancing characteristics are challenging, realistic and oriented to superior objectives. On the other hand, learning enhancing characteristics are solution-open, clearly appraisable as well as influenceable on a daily basis [12, 18, 24, 25, 30].

Following Rother´s approach, the target condition parameters or standards are achieved by continuous (short cyclic, incremental) improvement measures that are supported by the improvement and coaching kata. In addition to this approach, the parameters of a target condition are also accomplishable by discontinuous improvements (innovation leaps) [14, 19, 32, 34, 38]. When evaluating logistic processes or logistic value streams, the following practical relevant challenges arise from the fundamentals of defining and specifying as well as from accomplishing learning enhancing and performance enhancing target conditions.

3. Identification of challenges in practical work improvements applying target conditions

The definition of performance enhancing and learning enhancing target conditions with respect to their parameters is a great challenge in the work improvements in a specific value stream; e.g. the current condition cannot be assessed in enough detail due to several reasons and therefore the full potential may be unknown. In this paper, the scientific gap in practical work improvements applying target conditions is presented and discussed by showing, how learning enhancing and performance enhancing target conditions as a new standard can be defined, specified and implemented in practice. The focus is on how new standards of the selected parameters can be specified by using the MTM system of process building blocks, which has not been dealt with in the professional or scientific literature from this point of view so far.

The approach of applying target conditions systematically is presented on a practical case of application. Hereby, the value stream of packing original spare parts out of a package (e.g. metal box, metal cage, small parts bin) into a cardboard box is considered. It is also shown how the MTM system of process building blocks (MTM-UAS and MTM Logistics) is used for specifying standards or parameters of target conditions.

4. Work improvements applying target conditions presented with an example of the value stream of packing

Practical work improvements work at in the value stream of packing is presented based on the selected parameters of the current condition and the target condition 1: (1) "working system", (2) "working method" with (3) "basic time" and (4) "productivity". The planned improvement measures and indicators are described for each parameter and subsequently summarized in a table. However, a preliminary description of the analyzed and defined value stream of packing in current condition is prefixed.

4.1 Describing the considered value stream of packing

The original spare parts arrive in packages (here: metal boxes) from two different sources, an automated pallet transport system and an internal milk run system, in the considered value stream. Forklift drivers take the metal boxes to different allocation areas with respect to customer assignments. From there, the forklift drivers take the metal boxes to the packing area when specific customers need to be processed. The packing area is divided into several packing groups – the actual working systems for packing. Here, packers move the picked original spare parts from the metal boxes into the cardboard boxes and fulfill the value added operations in this value stream.

The basis for all calculations and concepts for defining target conditions is the so called representative cardboard box. Thereby, all quantities and varieties of the product range of original spare parts (dimensions, bulkiness, weight, etc.) are – together with metal boxes, metal cages, small parts bins – considered sufficiently accurate for packing a single cardboard box. The supply of metal boxes with parts to be packed in the working systems is a push supply. Service level relevant packing orders may be delayed for any reason, so rush orders are necessary in the value stream which detract from continuous packing of incoming metal boxes, metal cages or small parts bins from the two sources. In addition to the value added activities in the working systems, the packers also have to perform support activities like preparing or completing a cardboard box and handling packing material. After completing cardboard boxes in the working systems, the forklift drivers take them to a tying machine. Thereafter, the customer ready cardboard boxes are taken by the forklift drivers to an allocation area for loading containers.

4.2 Ideal state and derived effects on parameters of target conditions of the value stream of packing

Based on a comprehensive analysis of the current condition and the orientation to ideal state, several standards of parameters are defined based on the selected characteristics of the ideal state. Table 1 presents characteristics of the ideal state in the first column. In the second column, parameters are listed which define standards for performance enhancing and learning enhancing target conditions derived from the ideal state.

Table 1 Defining parameters or standards of target conditions derived from ideal state

selected characteristics of ideal state	***selected parameters defining standards of target conditions (performance and learning enhancing)***
continuous one-piece-flow	• *value stream* • <u>*working system (C2)*</u> • *layout and material flow* • <u>*productivity (C4)*</u> • *area utilisation* • *shift model* • *lead time*
100% added value	• <u>*working method (C3)*</u> o <u>*MTM method description*</u> o <u>*basic time*</u> • *number of workers* • <u>*productivity (C4)*</u> • *value stream* • *working system* • *layout and material flow*

To point out the improvements between the current condition and the target condition, the following two parameters of Table 1 are selected: “working system” as general process information and "working method" as process pattern. Thereby, the practical realization of the defined performance enhancing and learning enhancing target condition 1 is documented as well as the link between the ideal state and the target condition. Finally, the effects of the continuous and discontinuous improvement measures on the value stream of packing are reported by the third parameter "productivity" (performance indicator).

4.3 Parameter "working system"

The parameter „working system" is oriented to the characteristics "continuous one-piece-flow" of the ideal state. This parameter is categorized as (C2) "general process information" for defining standards of performance enhancing and learning enhancing target conditions. Fig. 3 shows the working system in the **current condition** where packers are packing. Here, they have to choose between 16 customer specific metal boxes in each working system to choose for packing parts into cardboard boxes. The sizes of areas are: 16.0m x 6.0m for each working system; 1.2m x 0.8m for a metal box; up to 2.2m x 1.4m for cardboard boxes. In this configuration of metal boxes and cardboard boxes in the working systems, the FIFO packing (first-in-first-out) is not applicable because packers cannot reproduce the sequence of incoming metal boxes. As a result, the packers choose metal boxes for packing with respect to subjective criteria. Hence, the above mentioned rush packing jobs are necessary and this leads to low service levels.

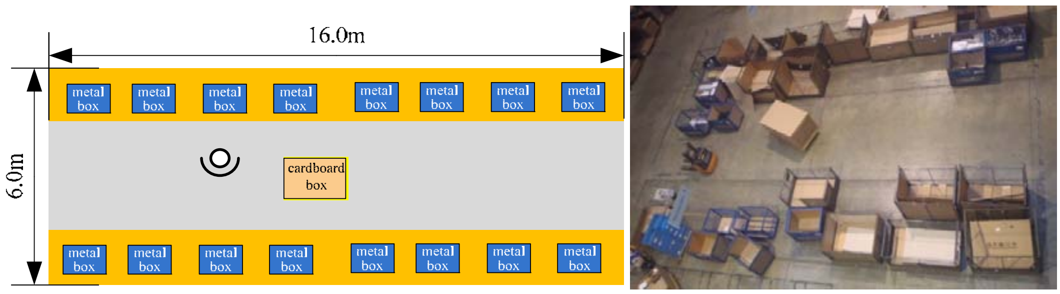


Fig. 3 Working system in current condition

As a new standard for the working systems of packing, a new layout design of packages (metal boxes, etc.) and cardboard boxes is planned and implemented. Therefore, the improvement to the parameter „working system" in **target condition 1** is an innovation leap, because redesign of the working systems is done within a short period of time. Here, a new "4:2-packing principle" is introduced. This implies that all parts from four incoming metal boxes are packed into one but not more than two cardboard boxes available in the working system at the same time. Reasons for that are based on different filling levels of metal boxes and the attributes of versatility of original spare parts. The packers get a replicable FIFO principle, because the parts of the four delivered metal boxes must be packed into cardboard boxes in order to get new metal boxes delivered into the working system again.

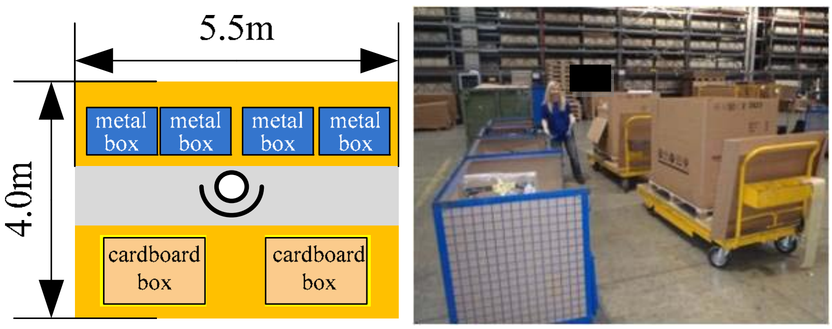
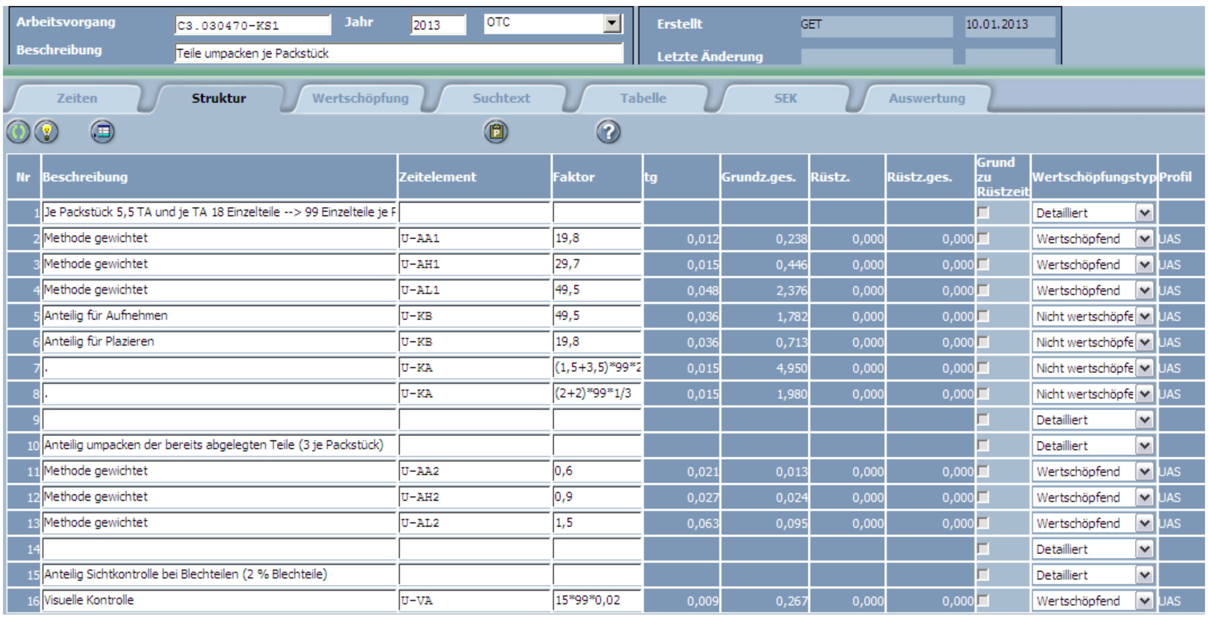


Fig. 4 Working system in target condition 1

4.4 Parameter "working method"

In the underlying value stream of packing, the working method (see Table 1) represents all necessary activities for packing parts into cardboard boxes; the activities are based on type, frequency, weight, bulkiness as well as on handling distances of original spare parts. The process pattern (C3) is represented by the MTM method description (see Fig. 5) and its result, the basic time t_g (process indicator, C3). Thus, the working method describes all necessary activities for packing the so called representative cardboard box with original spare parts and with respect to the packing adjustment. This parameter is influenced by the parameter of working system and derived from the characteristics "100% added value" of the ideal state. This leads to improvements to value added activities, reductions in support activities and elimination of waste. Subsequently, the influences of characteristics of the ideal state on the MTM method description and its result (basic time) are presented.

In the **current condition**, the applied working method is evaluated by the MTM-UAS (Methods-Time Measurement – Universal Analyzing System) and the MTM Logistics. So, the basic time t_g for packing of the representative cardboard box is determined. The introduced 4:2-packing principle caused by the layout of cardboard boxes and packages sets new standards for the working method for the workers as well as for the forklift drivers (see Fig. 6). Regarding the standards, underlying manual working methods are specified (described) and quantified (basic time) by the MTM method descriptions. For **target condition 1**, a new MTM method description (see Fig. 5) as planning analysis related to the improved working system is created. Here, the factors influencing the value added and support activities are improved based on a new layout of metal boxes and cardboard boxes in the working systems. Waste (e.g. walking) is eliminated as much as possible; here, due to a reduced size of the area of the working systems. This leads to a reduced basic time for packing the representative cardboard box. The implementation of the new working method is an innovation leap, however, learning and applying the new process pattern step by step is done by continuous improvements.



Arbeitsvorgang C3.030470-KS1 Jahr 2013 OTC
Beschreibung Teile umpacken je Packstück
Erstellt GET 10.01.2013
Letzte Änderung

Zeiten | Struktur | Wertschöpfung | Suchtext | Tabelle | SEK | Auswertung

Nr	Beschreibung	Zeitelement	Faktor	tg	Grundz.ges.	Rüstz.	Rüstz.ges.	Grund zu Rüstzeit	Wertschöpfungstyp	Profil
1	Je Packstück 5,5 TA und je TA 18 Einzelteile --> 99 Einzelteile je F								Detailliert	
2	Methode gewichtet	U-AA1	19,8	0,012	0,238	0,000	0,000		Wertschöpfend	UAS
3	Methode gewichtet	U-AH1	29,7	0,015	0,446	0,000	0,000		Wertschöpfend	UAS
4	Methode gewichtet	U-AL1	49,5	0,048	2,376	0,000	0,000		Wertschöpfend	UAS
5	Anteilig für Aufnehmen	U-KB	49,5	0,036	1,782	0,000	0,000		Nicht wertschöpfe	UAS
6	Anteilig für Plazieren	U-KB	19,8	0,036	0,713	0,000	0,000		Nicht wertschöpfe	UAS
7	.	U-KA	(1,5+3,5)*99*2	0,015	4,950	0,000	0,000		Nicht wertschöpfe	UAS
8	.	U-KA	(2+2)*99*1/3	0,015	1,980	0,000	0,000		Nicht wertschöpfe	UAS
9									Detailliert	
10	Anteilig umpacken der bereits abgelegten Teile (3 je Packstück)								Detailliert	
11	Methode gewichtet	U-AA2	0,6	0,021	0,013	0,000	0,000		Wertschöpfend	UAS
12	Methode gewichtet	U-AH2	0,9	0,027	0,024	0,000	0,000		Wertschöpfend	UAS
13	Methode gewichtet	U-AL2	1,5	0,063	0,095	0,000	0,000		Wertschöpfend	UAS
14									Detailliert	
15	Anteilig Sichtkontrolle bei Blechteilen (2 % Blechteile)								Detailliert	
16	Visuelle Kontrolle	U-VA	15*99*0,02	0,009	0,267	0,000	0,000		Wertschöpfend	UAS

Fig. 5 MTM method description for packing a representative cardboard box as standard in target condition 1

MTM-UAS (see Fig. 5) and MTM Logistics are applied to describe and quantify manual activities; for forklift movements MTM Logistics is used (see Fig. 6).

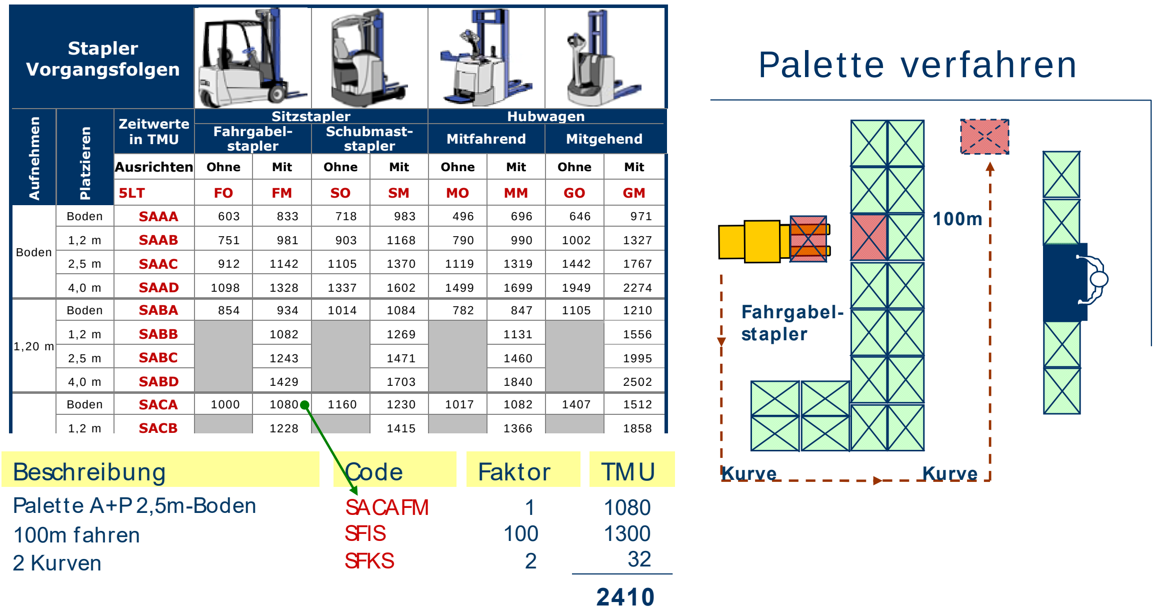


Fig. 6 MTM method description for forklift movements to provide package for packing a representative cardboard box as standard in target condition 1

4.5 Parameter “productivity”

Productivity is the main indicator of performance when considering the underlying value stream of packing (see Table 1). Among others, it is dependent on both parameters, “working system” and “working method”. The parameter “productivity” is categorized as “performance indicator” (C4) of a target condition. When calculating productivity for packing the representative cardboard box, parameters such as working system, working method and particularly the resulting basic time t_g are crucial characteristics of the input factors. The input size is the number of different inbound packages delivered to the working systems; the output size is represented by the amount of inbound package – including all its differently packed spare parts – into outbound cardboard boxes. Besides, the target value for productivity for the value stream of packing is related to the amount of inbound packages because this value cannot be influenced, e.g. different transport modes, variable filling degrees of cardboard boxes by worker, etc.

Here, workforce productivity is calculated as follows: the number of packed metal boxes divided by the total number of operational workers per shift. In the **current condition** at point of time t_0, each worker is packing parts of 5.55 inbound packages into cardboard boxes per defined time unit in average. This means a basic time t_g of 18.35 min per representative cardboard box. In target condition 1 at point of time t_1, a rise by 36% of incoming metal boxes is expected. Additionally with the planned improvement measures for **target condition 1** which have been specified and quantified by the MTM method descriptions in advance, an average productivity of 7.56 inbound packages per employee per time unit is planned. Hence, the targeted basic time of 15.87 min per representative cardboard box is planned and specified. With respect to the actual improved parameters, the actual productivity is 7.94 inbound packages per defined time unit. To sum up, the workforce productivity rises by +43% compared to the current condition; basic time t_g decreased to 13.69 min per representative cardboard box. Process indicators (C3) and performance indicators (C4) of the parameters are summarized in Table 2.

Table 2 Summary of process indicators and performance indicators

Standard / Measured variable	Current condition	Target condition 1 Calculated	Target condition 1 Reached
Incoming metal boxes per time unit	5.55	7.56	7.94
Productivity [%] based on metal boxes	100	136	143
Basic time t_g [min] per resp. cardboard box	18.35	15.87	13.69

5. Conclusion and Outlook

This paper shows how the MTM system of process building blocks contributes to planning and specifying selected parameters of target conditions or standards and how it supports the work improvements to logistic value streams. Furthermore, the scientific gap in practical work improvements applying target conditions is presented and discussed by showing how target conditions derived from the ideal state can be planned, specified and implemented. Hereby, special focus is on how new standards of selected parameters can be specified and described with the MTM system of process building blocks.

On the one hand, the parameters "working system" and "working method" are performance enhancing as new standards and performance indicators affect the packers and guide them to target orientated action. Furthermore, packers must also engage and work in new processes and in new working systems; they are encouraged to make further improvements; e.g. better alignment of metal boxes in the working system. On the other hand, both parameters are learning enhancing as they are modifiable when deriving or defining and striving for target conditions. As a result, these two parameters are (daily) influenceable and especially solution open. When defining target conditions, the parameter "productivity" is both performance enhancing and learning enhancing. Productivity is a challenging, realistic and clearly appraisable performance indicator. As a result, future improvement actions are measureable too and give feedback to executive personnel and operative workers (packers) about the level of fulfillment when accomplishing a target condition.

This specific case of application proved that an increase in productivity results from combining continuous improvements and innovation leaps. In any case, practical work improvements to a value stream applying target conditions can be used to solve logistic problems. In further publications, using additional parameters, e.g. overall layout, value stream, lead time or area utilization it will be shown how other improvement measures of target condition 2 have been planned and implemented in the value stream of packing. The work improvement applying target conditions is currently used in production logistic processes in the assembly of electrical components and is being further developed. The experiences gained in these practical work improvements are currently transferred to other areas and plants/sites of the original equipment manufacturer. Further research has to address the necessary generalization, transferability and specification of possible ideal state characteristics. The following question will be discussed: how can the characteristics be associated with the product development process?

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