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Session	Supply Chain Management 1
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Time	11:15 - 12:45
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Chairs	Peter Kuhlang, Chao Fang

Productivity Improvement in Logistical Work Systems of the Genuine Parts Supply Chain

Peter Kuhlang[1], Alexander Sunk[2]
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Within the entire value stream of 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. Considering the total value stream of supplying original spare parts, picking and packaging are two of the most important activities in the distribution system and they are mainly performed by intensive manual tasks. As practice shows, the methods Value Stream Design and Methods-Time Measurement (MTM) have proven to be suitable for improvement work and consequently for increasing productivity especially in work systems with manual work. This paper shows how the process building block system 'MTM logistics data' contributes to planning and specifying parameters of target-conditions of value streams. It also presents a methodical approach to support practical improvement work in logistical value streams and within their work systems.

A Pricing Strategy to Align Supply Chain Interests for Product Recall

Hongyan Dai, Nan Yang, Nina Yan
Central University of Finance and Economics, China

Traceability systems are regarded as an effective way to address product recalls. It cannot work effectively without the participation of all the chain members. However, the incentives in the supply chain are not naturally aligned, and may need interest-alignment mechanism to motivate the chain members to participate. This paper thus proposes a pricing strategy to avoid free-rider problems by correcting the liability misallocation, therefore aligning the supply chain interests to improve traceability. The trade-offs between the associated benefits and costs of improving traceability are investigated, in order to design a cost-effective traceability system. Moreover, how to better manage product recall by incorporating new technology, such as RFID, and the conditions that are conducive to its adoption are investigated.

SCM Logistics Scorecard: A Simplified Benchmarking Tool for Supply Chain Operational Performance

Sadami Suzuki
Tokyo Institute of Technology, Japan

This research intends to introduce SCM Logistics Scorecard (LSC) as a simplified benchmarking tool based on self-evaluations of SCM operational performances. By utilizing LSC, SCM operational performances in different East Asian countries, namely, Japan, China and South Korea were investigated. The scores of assessment items in LSC were compared among countries. Subsequently, a factor analysis was conducted in order to identify significant influential factors that represent the operational performance of SCM in each country. Similar structure has been extracted in these three East Asian countries and from Japanese data, it has been verified that IT is necessary, but not sufficient to lead to enhanced corporate financial performances such as ROA, cash flow and inventory turnover.

Supply Chain Management in Service Industry: A Process Capabilities Perspective

Sakun Boon-itt[1], Chee Yew Wong[2], Christina Wong[3]
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[3]*Hong Kong Polytechnic University, Hong Kong SAR*

This paper develops and tests the measurement scales for service supply chain management (SSCM) process capability constructs. An extensive literature review and interviews were conducted to define the constructs and initial measurement items. The measurement items were refined by using the Q-sort method. Confirmatory factor analyses of a large-scale survey confirmed the unidimensionality, reliability, and validity of the multidimensional construct of SSCM process capability. The findings show that SSCM process capability consists of seven-dimensional constructs, each represented by a unidimensional multi-item scale Practitioners may use the scales to benchmark and develop their capabilities in managing SSCM processes beyond the typical internal service supply chain capabilities. The development of measurement scales elevates the service operations field, which previously relies on largely conceptual frameworks and descriptive accounts of SSCM processes. The measurement scales of SSCM process capability can be also used by future empirical studies to advance theory in service supply chains.

Solving the One-Shot Decision Theory Based Newsvendor Models

Xide Zhu, Peijun Guo
Yokohama National University, Japan

The one-shot decision theory has been utilized to solve newsvendor models for innovative products. In fact, the one-shot decision theory based newsvendor models are a special kind of bilevel programming problems. The existing approaches may not be applicable for solving these models since they include nonconvex nonsmooth lower level optimization problems. In this paper, we translate these models into general optimization models with considering the characteristics of the optimal solutions, which effectively handle the difficulties of the original newsvendor models. The theoretical results are given and a numerical example is used to show the effectiveness of the proposed methods.

SD Modelling of Healthcare SC in Rural Parts of Uttarakhand, India

Dinesh Kumar, Dinesh Kumar
Indian Institute of Technology Roorkee, India

This paper presents the system dynamic modelling and simulation of folic acid tabs supply chain in rural areas in district Haridwar, Uttarakhand, India. During the investigation and data collection, an enormous shortage of folic acid tabs was observed at various stages leaving a large population unserved. The stock out occurs due to uncertain lead time and demand. Therefore the model is developed with a safety stock at each stage on Stella® platform. The simulation has been run for a time span of twelve months. Further sensitivity analysis is performed showing the effects of lead time on the stock at women's hospital, schools and community health centers. The results show the elimination of stock out of medicine at all the downstream stages maintaining a safety stock. The current work may support the strategists to take essential steps to improve the sustainability of the healthcare supply chain in parts rural of the state by diminishing the shortage of medicines.

A Mixed-Integer Programming Model for the Production-Inventory-Distribution Routing Problem

Noha Mostafa, Amr Eltawil
Egypt-Japan University for Science and Technology, Egypt

In this paper, a mixed-integer programming model is proposed to solve the Production-Inventory-Distribution-Routing Problem (PIDRP), with the objective of minimizing the total cost while satisfying the required levels of demand and service. A generic problem description and mathematical model formulation are proposed to address the PIDRP. The novelty of the model is that it deals with multiple products, allows split deliveries, adopts a heterogeneous fleet of vehicles, and puts a limit on the duration of the route performed by each vehicle. The proposed model is successfully validated and tested using small-sized instances from literature.

Productivity improvement in logistical work systems of the genuine parts supply chain

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Abstract - **Within the entire value stream of 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. Considering the total value stream of supplying original spare parts, picking and packaging are two of the most important activities in the distribution system and they are mainly performed by intensive manual tasks. As practice shows, the methods Value Stream Design and Methods-Time Measurement (MTM) have proven to be suitable for improvement work and consequently for increasing productivity especially in work systems with manual work. This paper shows how the process building block system "MTM logistics data" contributes to planning and specifying parameters of target-conditions of value streams. It also presents a methodical approach to support practical improvement work in logistical value streams and within their work systems.**

Keywords - **Logistics, value stream, methods-time measurement (MTM), MTM Logistics**

I. MOTIVATION AND INTRODUCTION

Considering the total value stream of supplying original spare parts, packaging is one of the most important activities in the distribution system as well as in the supply chain [1]. Packing is defined as moving of customer specific original spare parts out of a package into a cartonage (i.e. cardboard package), for e.g. the purpose of arranging the customers order. It starts after picking (ordered spare parts) and ends with ready set cartonages of customer ordered parts and quantities ready for delivery [2]. Several authors point out the intensive manual work structure in picking as well as in packing, because handling and moving of both original spare parts and cartonages is difficult to standardize due to their variability and thus hardly automatable [1].

At packing, especially value adding and non-value adding manual activities affect productivity and must therefore be systematically planned and improved [2, 3]. Caused by this effect, cost pressure for companies in high-wage countries gets even stronger besides globalization, the challenging competitive situation and the current reindustrialization. Thus, especially for packing of original spare parts, new and higher requirements arise for productivity management of companies. So, systematic application and further development of modern improvement methods and improvement procedures are necessary to meet these requirements [4]. The methods Value Stream Design and Methods-Time Measurement (MTM) have proven to be suitable for improvement work and consequently for increasing productivity; e.g. for identifying and reducing waste activities as well as evaluation of indicators [5, 6]. This paper points out how the packing value stream in the supply of original spare parts gets developed towards an ideal-state by defining performance-enhancing and learn-enhancing target-conditions. It also shows how the MTM system of process building blocks contributes to planning and specifying selected parameters of target-conditions or standards and to support the improvement work on logistical value streams. Therefore, necessary fundamentals are described in the following subsection.

II FUNDAMENTALS OF VALUE STREAM MAPPING

Productivity is the yield of the production factors "workforce", "machine" and "material". This yield is represented by the ratio "performance divided by factor input". When calculating productivity, output (performance) is represented by a specific quantity, e.g. produced goods. Input is quantified by the use of production factors; e.g. the figure for workforce productivity by number of workers or time units [7, 8, 9]. Upon closer examination of factors influencing the productivity, it becomes obvious that for human and machinery resources especially the dimensions "work method design", "level of performance provided" and "degree of utilization of resources" affect productivity [10]. Anyway, work method(s) design is the most important dimension for influencing productivity [10, 6, 11]. Manual work methods can be described and specified by MTM-method descriptions and the resulting basic time tg as well as implemented and improved in future steps.

A. MTM-method Descriptions for Designing Logistical 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 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. Hence, this well-grounded time determination based on an international performance level is often called

as 'International Prototype Metre of human work' [12]. For modeling logistic processes, the application of the MTM system has a long tradition and has in recent years also gained in importance due to increasing logistics costs. The increased costs are caused on the one hand by high technical, organizational and staffing requirements, which are today on a cross-company logistics and on the other hand due to insufficient accuracy in the consideration of logistical processes. Here, the application of MTM systems – in specific the MTM Logistics – contributes significantly to design and rationalization of logistical processes, e.g. when planning and designing logistical processes like picking, packing, testing, transporting. These activities, which may show different complexity, are so the so-called logistics Standard Operations [13].

C. Using Value Stream Mapping at Practical Improvement Work

The paradigm of striving for an ideal-state – it can be considered as a vision – is the basis of 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 [14]. This ideal-state is used as a navigation link ("true north") or orientation guide and represented by characteristics like 100% added value, continuous one-piece-flow, zero defects and lack of impairment for employees [15]. The ideal-state gives direction for deriving and defining several target-conditions for a value stream [15, 16]. According to Toyota's point of view, the next target-condition to be accomplished when striving for ideal-state can be interpreted as a new standard [4]. Hempen describes a modern approach for defining target-conditions, which is a difficult issue in practice. Here, they are defined by parameters which are categorized as follows: (C1) calculated indicators, (C2) general process information, (C3) process pattern & process indicator and (C4) performance indicator [17]. The parameters for specifying and defining target-conditions are based on performance-enhancing and learn-enhancing target setting characteristics. On the one hand, performance-enhancing characteristics are e.g. challenging, realistic and oriented to superior objectives. On the other hand, learn-enhancing characteristics are e.g. solution-open, clearly appraisable as well as influenceable on a daily base [17, 18].

Following Rother´s approach the target-condition parameters or standards get 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) [4, 14]. When evaluating logistical processes or logistical value streams, the following practical relevant challenges arise from the fundamentals of defining and specifying as well as accomplishing learn-enhancing and performance-enhancing target-conditions.

III. IDENTIFICATION OF CHALLENGES IN PRACTICAL IMPROVEMENT WORK APPLYING TARGET-CONDITIONS

The definition of performance-enhancing and learn-enhancing target-conditions respectively their parameters is a great challenge in the improvement work in a specific value stream; e.g. the current-condition is not assessable detailed enough due to several reasons and therefore the full potential may be unknown. In this paper, the scientific gap in practical improvement work applying target-conditions gets presented and discussed by showing in practice, how learn-enhancing and performance-enhancing target-conditions as a new standard can be defined, specified and implemented. Focus is regarded to how new standards of selected parameters can be specified with MTM system of process building blocks, which has not been treated in applied and scientific literature in this point of view so far.

The approach of applying target-conditions systematically is presented in 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 cartonage is considered. It is also shown how the MTM system of process building blocks (MTM-UAS and MTM Logistics) is used for the specification of standards or parameters of target-conditions.

IV. IMPROVEMENT WORK APPLYING TARGET-CONDITIONS PRESENTED IN THE EXAMPLE OF THE PACKING VALUE STREAM

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

A. Describing the Considered Packing Value Stream

The original spare parts in packages (here: metal boxes) arrive from two different sources in the considered value stream; an automated pallet transport system and an internal milk-run system. Forklift drivers take the metal boxes to different allocation areas with respect to customer assignment. 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 work systems for packing. Here, packers move the picked original spare parts from the metal boxes into the cartonages and fulfill the value-adding operations in this value stream.

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

B. Ideal-state and Derived Effects on Parameters of Target-conditions of Packing Value Stream

Based on comprehensive analysis of the current-condition and the orientation to ideal-state, several standards of parameters are defined based on selected characteristics of the ideal-state. Table 1 presents characteristics of ideal-state in first column. In second column, parameters are listed which define standards for performance-enhancing and learn-enhancing target-conditions derived from 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 LEARN-ENHANCING)**
continuous one-piece-flow	• value stream • work system (C2) • layout and material flow • productivity (C4) • area utilisation • shift model • lead time

100% added value	• work method (C3)
	  ○ MTM-method description
	  ○ basic time
	• number of workers
	• productivity (C4)
	• value stream
	• work system
	• layout and material flow

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

C. Paramter Work System

The parameter “work system“ is oriented to the characteristics “continuous one-piece-flow” of the ideal-state. This parameter is categorized as (2) “general process information” for defining standards of performance-enhancing and learn-enhancing target-conditions. Fig. 3 shows the work system in current-condition where packers are packing. Here, they have to choose between 16 customer specific metal boxes in each work system to choose for packing parts into cartonages. The sizes of areas are: 16.0m x 6.0m for each work system; 1.2m x 0.8m for a metal box; up to 2.2m x 1.4m for cartonages. In this configuration of metal boxes and cartonage in the work systems, 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 the 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.

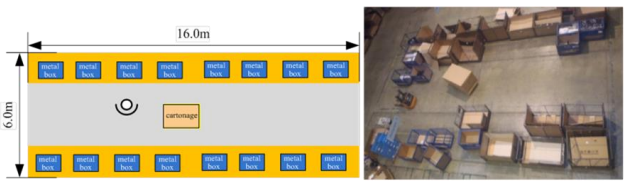

Fig. 3: Work system in current-condition

As a new standard for the working systems of packing, the new layout design of packages (metal boxes, etc.) and cartonages is planned and implemented. Therefore, the improvement of the parameter “work system“ in target-condition 1 is an innovation leap, because redesign of the work systems is done within a short period of time. Here, the 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 cartonages available in the work system at the same time. Reasons for that are based on different filling levels of metal boxes and the attributes of versatility of the original spare parts. The packers get a replicable FIFO-principle, because the parts of the four delivered metal boxes must be packed into cartonages in order to get new metal boxes delivered into the work system again.

D. Paramter Work Method

In the underlying packing value stream, the work method (see Table 1) represents all necessary activities for packing parts into cartonages; the activities are based

on type, frequency, weights, bulkiness as well as on handling distances of the original spare parts. The process pattern (C3) is represented by the MTM-method description and its result, the basic time tg (process indicator, C3). Thus, the work method describes all necessary activities for packing the so-called representative cartonage with original spare parts and with respect to the packing adjustment. This parameter is influenced by the parameter work system and derived from the characteristics "100% added value" of ideal-state. This leads to improvements of value-adding activities, reductions of support activities and elimination of waste. Subsequently, the influences of characteristics of ideal-state on the MTM-method description and its result (basic time) are presented.

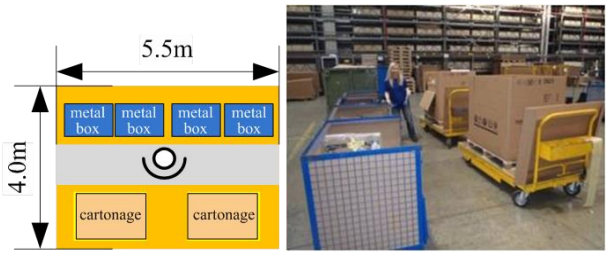

Fig. 4: Work system in target-condition 1

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

MTM Logistics is applied to describe and quantify forklift movements (see Fig. 6).

D. Paramter Productivity

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

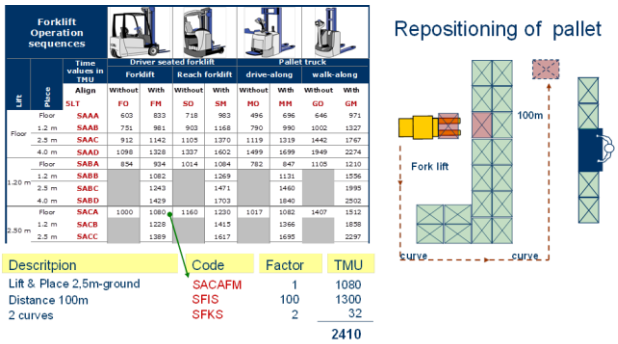

Fig. 6: MTM-method description for forklift movements to provide the package for packing a representative cartonage as standard in target-condition 1 [13]

Here, workforce productivity is calculated as follows: number of packed metal boxes divided by total number of workers per shift. In current-condition at point of time to, each worker is packing parts of 5.55 inbound packages into cartonages per defined time unit in average. This means a basic time tg of 18.35 min per representative cartonage. In target-condition 1 at point of time t1, a rise by 20% of incoming metal boxes is expected. Additionally with the planned improvement measures for target-condition 1 which have been specified and quantified by 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 cartonage is planned and specified.

TABLE 2:
SUMMARY OF PROCESS INDICATORS AND PERFORMANCE INDICATORS

STANDARD MEASURED VARIABLE	CURRENT-CONDITION	TARGET-COND. 1 CALCUL.	TARGET-COND. 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.cartonage	18.35	15.87	13.69

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 current-condition; basic time tg decreased to 13.69 min per representative cartonage. Anyway, process indicators (C3) and performance indicators (C4) of the parameters are summarized in Table 2.

V. 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 to support the improvement work on logistical work systems in value streams. Furthermore, the scientific gap in practical improvement work applying target-conditions got presented and discussed by showing how target-conditions derived from the ideal-state can be planned, specified and implemented. Hereby, special focus was regarded to how new standards of selected parameters can be specified and described with the MTM system of process building blocks.

This specific case of application proved that increasing productivity is the result of combining continuous improvements and innovation leaps. Either way, practical improvement work at a value stream applying target-conditions can be used at logistics 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 packing value stream. The improvement work applying target-conditions is currently used in production logistics processes in the assembly of electrical components on and gets further developed. The experiences gained in this practical improvement work 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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