Information systems for lean value adding chains

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Abstract

The paper presents the Lean Manufacturing concept from the perspective of the two narrow issues – management of the value adding chains, and computer systems including e-business applications. The performed analysis concerns "Lean" requirements for IT solutions within a single enterprise, as well as within the whole chain of cooperating companies. The analysis is based on the future value stream map, both in micro (single enterprise) and macro (supply chain) scale. The last but one section describes proposed approach how to incorporate "lean" principles into requirements for company information system.

Keywords

Lean Manufacturing, e-business, information systems, value adding chains.

INTRODUCTION

Lean Manufacturing is a worldwide proven approach for the improvement of production processes through eliminating wastes. The results are better quality, lower costs, and shorter lead-time. It also includes decreasing manufacturing lot sizes, which allow enterprises the ability to reach a higher level of flexibility [20].

"Lean" philosophy is still successfully exploited in industry, although it has been known for half a century, first in Japan as Toyota Production System [15] and then in USA and other countries. It does not mean that requirements for production have not changed. On the contrary, nowadays the business environment changes dynamically and forces enterprises to react faster and faster to these changes.

One of the major recent changes is the application of e-business solutions. E-business encompasses a set of ICT solutions, as well the ideas based on extensive exploitation of wide area networks (including *internet*) to support business processes. It includes also activities within the supply chain. Generally "e-business" gives the potential for better flexibility of the production enterprises, and more collaborative way of cooperation, or in broader perspective for managing the whole supply chains.

Most "e" solutions being currently developed for production enterprises base on ERP and SCM schemes and are not applicable for "Lean" value adding chains. Example could be distributed supply chain made of independent organizations. SCM systems provide functions for centralized planning or for paperless order realization.

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Assumption is that SCM system alone, thanks to intensive information exchange through wide area networks WAN, could improve some crucial performance measures (e.g. inventory levels in Distribution Centre). On the contrary "Lean Manufacturing" focuses on shop floor to shop floor communication, and exchanging simple data like "electronic kanbans". It assumes also that only better communication system within supply chain is not enough to improve such measures as total lead time or cost per unit. Firstly the internal production system of companies participating in supply chain have to be changed. Then the logistics system between companies shall to be improved. All the changes will result in the new information flows. In consequence a new "e" business solution for "Lean" supply chain have to follow all the above mentioned changes.

Taking into account the outlined problems the analysis will be performed according to the following questions:

- What are the elements of nowadays environment which decide how production enterprises work?
- Is Lean Manufacturing applicable concept for production value adding chains in such environment?
- Are the available e-business solutions applicable to "Lean" value adding chains?
- How to create e-business solutions for "Lean" value adding chains?

The paper is based on the experiences from the projects and consulting provided by the Centre for Advanced Manufacturing Technologies CAMT to the Polish enterprises and international companies investing in Poland [10, 18] as well as on the other published sources [1, 3].

THE BUSINESS ENVIRONMENT OF THE PRODUCTION ENTERPRISE

In Europe, as well as in the whole world, manufacturing enterprises have been suffering from growing pressure to cut the costs and improve flexibility. The first issue is crucial for manufacturing companies, especially if the product is not complex and its market value is easy to evaluate (e.g. suppliers in automotive industry). The flexibility mentioned above could be defined in two ways:

- The narrow sense of flexibility means shorter production lots and bigger variety of products and, in consequence, better reactiveness on the market demand in short term (the key issue here from the shop floor perspective is short lead time).
- The broader sense of flexibility means the ability of fast introducing the new products to the marketplace and, in consequence, better reactiveness on the market demand in long term (it sets the strong requirements for production system as well as for the product development process /including research/, design and production preparation).

Next important issue of today's business is to see production from the perspective of the whole value adding chains, not only the single enterprise. This

means optimization of the business processes performed between cooperating enterprises. It could be seen from the simple supplier - customer relation point of view, as well as from the whole value creating stream point of view, beginning at the raw material tier, through components suppliers, to the final assembly and further to the distribution. Anyway the optimization of the supply chain has to be supported by improvement actions in the single enterprises.

In the result production companies have to cut the costs and improve the flexibility. Additionally they have to implement more collaborative business models with their customers and suppliers. The goal is still to lower overall cost and improve flexibility within the whole value adding chain. It could not be forget that quality is also important but it is rather prerequisite to stay in business and not the competitive advantage.

WHY "LEAN"?

The basis of "lean" is to find and eliminate waste. This very simple idea contains several concepts, which built the "lean" strategy (see [20]). The main notion is "takt time". This means the period of time in which (statistically) the customer buys one product. So to react on customer's needs the company should produce one product within every takt time. Again it sounds simple, but to apply this concept to a complex production system could be a challenge. The understanding of the importance of takt time is first step to gain main goals of "Lean" which are:

- short lead time,
- high quality,
- low inventory level,
- large variety of products,
- low cost.

These goals are strongly related one to another. Short lead time usually depends on the level of WIP. Product variety depends on set-up times, but also on lead time (short lead time allows the ability to produce to demand). Finally the costs depend on the quality, inventory level, and lead time (more detailed analysis of these relations is presented in [17]). This description of "lean" is simplified but gives overall understanding of where to go. The "Lean" philosophy has to be evaluated from the business environment requirements point of view.

Lower Costs: . Reduced costs are a main result of eliminating wastes. In a lot of cases after implementing "Lean" the companies lowered the unit costs by dozens of percent. It is usually the result of reduced inventories (raw materials, WIP as well as finished goods), less machine down times (thanks to Total Productive Maintenance – see [16]), shorter lead time, producing "on time", rather than "on forecast", lower quality costs (thanks to the quality at the source rule) and better workers assignment.

Better Flexibility: The growing variety of products generates more inventories in all areas – finished goods, WIP, raw materials (or components). To avoid increased inventories, enterprises have to produce "just-in-time", and/ or to improve forecasting. "Lean Manufacturing" focuses on the first approach. Producing large variety of products on time requires very short lead time, and very effective

scheduling and control system for the shop-floor. It encompasses the next key technique of "Lean" – visual control. The known examples from the industry show that inventories could be reduced by up to 80% and the same with lead time [1, 15]. Of course it depends on each particular case, but usually the reduction is significant. Next, the flexibility of production system is related also to the ability of continuous improvement. "Lean" realizes it by team work and exploitation of worker's creativity on each organizational level (Kaizen [2]).

Focus on the whole supply chain: Building a close "win-win" relation between partners of supply chain is the base of the "Lean" concepts. But to improve the whole value adding chain, first the participants have to achieve internal readiness. Internal readiness is usually seen as an ability to exchange data between internally integrated IT systems. Actually the main focus of readiness is on the production system and not exclusively on information flows. An example could be a customer that requires frequent deliveries in small transport batches, "just-in-time". The supplier could profit from such requirements, if he had a flexible production system. Otherwise he will need to increase the finished goods inventory and finally to manage the higher costs. Similar situations could be described for the bigger chains of several cooperating partners.

"Lean" is seen today as very useful concept to address key problems which production companies have to manage: lower costs, improved flexibility as well as high quality level.

ARE "E" SOLUTIONS APPLICABLE FOR "LEAN" VALUE ADDING CHAINS?

To optimize the whole value stream, one of the key issues is the information flow and processing [5]. It means the flow among the enterprises. This is obvious that exchanged data has to be previously captured and processed inside the enterprises. That is why the performance of the IT system for the supply chain is strongly dependent on the internal IT systems of the companies participating in the chain.

E-business gathers many tools and concepts based on *internet* network or generally on latest ICT solutions. We can enumerate many business processes recognized as reasonable to be supported by *e-business* tools:

- Customer relationship management (advertisement, service, sales, collecting marketing data, pricing),
- Electronic exchange marketplaces (goods exchange between enterprises, searching new business partners, information flow between members, auctions and customer's auctions),
- Product development (concurrent engineering, engineering data exchange, project management in distributed team),
- Supply chain management (collaborative forecasting and planning, forecasts back propagation, paperless order realization, *Available-To-Promise* technique, order realization tracing).

Below some examples will be given that shows the potential of "e" solutions to address the issues of lower cost and improved flexibility.

Lower Cost: Realization of a closer customer-supplier relationship like CPFR (Collaborative Planning, Forecasting and Replenishment [19]) or VMI (Vendor Managed Inventory) has a positive impact on such measures like inventory level, forecasts accuracy, and order realization time. All of them have a positive impact on the product costs, and for e.g. on opportunity loss. Of course the closer collaboration in forecasting, distribution, production planning and control requires "e" solutions to capture appropriate data (e.g. on the inventories in the particular warehouse), aggregate them and exchange within the chain.

Flexibility: ICT technologies and particular *internet* network gives the possibility to build very flexible, re-configurable and relatively cheap applications for supply chains. It means that potentially these applications could follow the changes in the structure of the supply network. It is crucial to create flexible organizational structures like "virtual enterprises" [8, 9]. This is also obvious that "e" applications enable organizations to perform product development processes in a distributed environment according to concurrent engineering concepts, which is crucial to reduce "time-to-market" and consequently to improve flexibility in a broader sense.

Software providers offer a lot of e-business applications like SCM systems, CRM systems, ERP systems, "e" marketplaces. Several of the above listed processes are aided by IT solutions available in the marketplace. Among them most popular are CRM systems, SCM systems, and some functions of the latest ERP systems, and *e-marketplaces*. In the following analysis, only the SCM and ERP systems will be considered from the perspective of the production area. Both solutions derive the MRP or APS (Advanced Planning and Scheduling) planning approach both for single enterprise and supply chain (for examples see [6, 12]). For distributed (made from independent companies) supply chains, the systems provides the paperless purchase/sale functions which improves purchasing/sale processes between supplier and customer however the process is still performed outside of the shop-floor (through purchase/sales departments) and basing on forecasts and medium-term plans (MRP planning procedure). For distributed production sites of one corporation the centralized planning procedures are implemented which often concentrates on accumulation of production lots according to the EOQ rule.

Lean Manufacturing, as was mentioned earlier in this paper, focuses on direct shop floor to shop floor communication. The data exchanged are very simple. The single kanban card means that customer needs one bin of particular components in the next several hours (for discussion on "electronic" supplier kanban see [4, 7]). The optimization of the "Lean" supply chains encompasses making leaner the participants and then the whole value adding chain. It encompasses decreasing the lead time in the companies as well as decreasing the transport batches and increasing the replenishment frequency in the supply chain (e.g. through implementation of milk run replenishment loops [4]). It results in decreased overall lead time and improved flexibility of the whole value chain and is in the opposition to the concept of EOQ and accumulated orders.

To recapitulate the e-business gives real potential to implement Lean Manufacturing within value adding chains however the current solutions provided

by IT vendors does not suit "Lean" requirements. In the next section the analysis of information flows in "Lean" enterprises will be performed. On this basis the approach to create of e-business solutions for "Lean" value adding chains will be proposed.

INFORMATION FLOWS IN THE "LEAN" ENTERPRISE AND VALUE ADDING CHAIN

To define requirements for information systems in the "lean" value stream it is necessary to analyze the production process, production planning, and control within the single enterprise and the whole value adding chain. The first step is to map the value stream within single enterprise. The main result is the future state map (Figure 1).

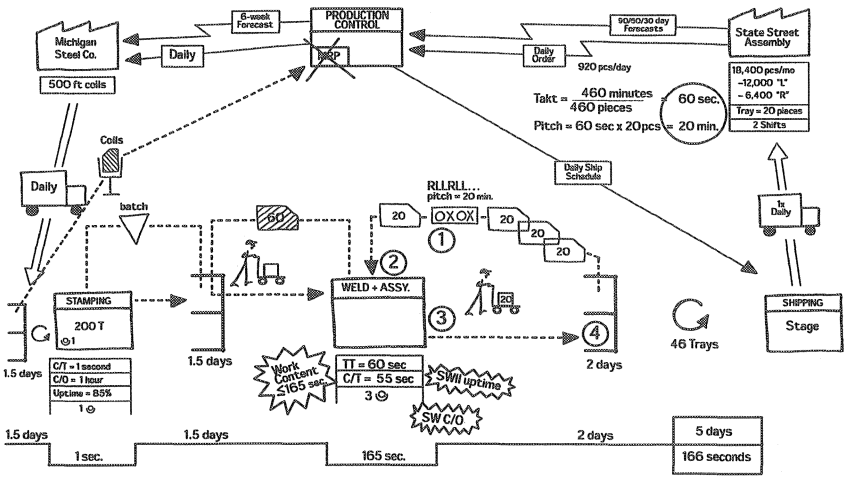

Figure 1 - Future state map - example [11]

In the presented example the pace of production is given by shipping area. The production takt time and the sequence depend on the customer's demand, and are set by Production Planning. This is opposite to classical MRP algorithm where the production schedules are made according to forecast, over a longer time period and based on economical order quantity (EOQ). In the system shown on Figure 2, the goals for planning and control process are short lead time, low inventories, and increased reactiveness on changing demand. Consequently the planning is oriented on the shipping area. From this point the replenishment signal is propagated back using kanbans and supermarkets. How production control is performed in the system? The material flows between the welding and assembly cell and the stamping is controlled by a supermarket, which has minimal-maximal levels of WIP for components. The average level could be calculated. It represents the component inventory needed for particular time of production (e.g. an hour). For products sold

rarely both levels could be set to zero and special kanban card or visual signal could be used.

The scheme of the material flows and production control through a supermarket is as follows: taking the bin of components is signalling the previous cell to produce them, and after some time the components are replenished in the supermarket (which is also a signal not to produce them in that moment). In the case of very expensive components, or when the variety is large the broadcasting technique is suggested (Figure 2).

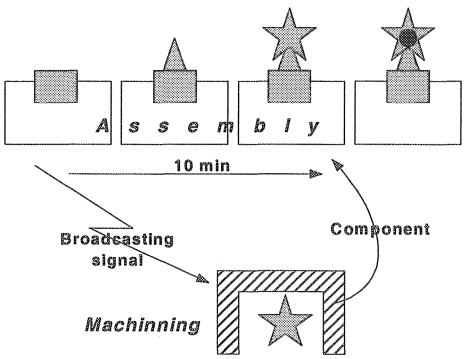

Figure 2 - Broadcasting technique in lean manufacturing

In the areas of production system where continuous flow was implemented the information flow is very simple. All the workplaces within the cell produce one part in the same pace and every event is immediately visible for the operators. Here the big difference between MRP and Lean approaches can be seen. In the "lean" production system the scheduling is really performed in time units like minutes, tens of minutes or hours. In fact as a base scheduling value the processing time of one unit is used. In a MRP driven production system batch processing time is used and it includes also the machine set-up times. However even in such factories operators see the importance of processing time of one unit. This could be noticed when producing the lot of the products taking several weeks, but in some urgent cases producing the short batch of that product is made within several days.

The perspective of the whole value adding chain could be analyzed using Macro Value Stream Mapping. The example on Figure 3 includes car distributor, producer, and the value adding chain for the car wipers. Like previously, the focus is on the short logistics lead time, low costs (what means also the low level of all the inventories) and high reactiveness on the market demand for the final product.

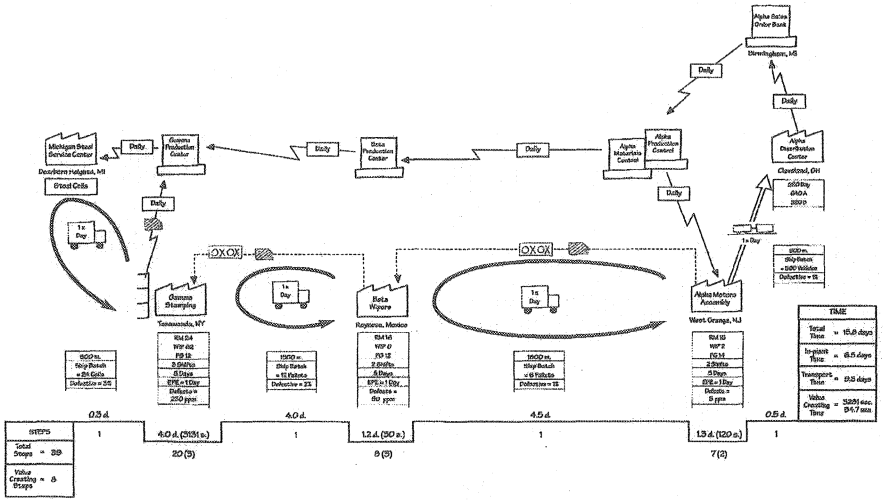

Figure 3 - Macro Value Stream Map - example [3, 4]

In the upper part of the map the information flows are shown. As could be seen on the Figure the pace maker for the whole value adding chain is the car assembly company (*Alpha Motors*). It receives the information from the distribution network and defines the daily schedule for its own shipping area. Also the demands are sent to *Beta Wipers* and then upstream to the raw material suppliers. In fact the production scheduling and control in the value adding chain uses the kanban technique. The "electronic kanban" is implemented here. The component bin taken from the inbound area of the customer is electronically scanned, and the signal is sent to the suppliers shipping area via wide area network. There the electronic message could be changed into a paper card put in the heijunka box. Thus the simple information controls the replenishment cycle within the whole value adding chain. Electronic kanban could also initiate the payment between cooperating parties. Unfortunately the offered SCM systems follow rather a different direction. The focus is in the paperless ordering process or logically centralized planning procedures.

It has to be underscored that the structure of the information system in Figure 3 is part of the overall optimization strategy focused on shortening of overall lead time, and decreasing production lots in the cooperating factories (e.g. through set-up time reductions) as well as among them (e.g. through milk run replenishment loops in transportation). It should not be forgotten also that the activities on the strategy level are more like a "win-win" orientation in customer-supplier relationship.

HOW TO APPLY "E-BUSINESS" IN THE "LEAN" VALUE ADDING CHAINS

The main focus of reengineering the supply chain towards "Lean Manufacturing" is on changes in the production system of the participants and the

logistics system of the supply chain. Then the required information flows are determined. Thus, in such approach, information system model is developed simultaneously with the overall model of the supply chain. It ensures that information system will suit the "Lean" strategy of the company and will not be built separately. Such attitude is in opposition to the existing approaches of applying ERP systems where practically the focus is on the analysis of the office processes and information flows in separation from production process.

Main steps of the proposed approach are shown in Figure 4. Below the elements of the scheme are described. The efficient and proven tool for analysis of production processes is Value Stream Mapping (VSM). On the value adding chain level the Macro VSM is used (to improve logistics system). VSM is locally performed by the participating enterprises (to improve production system). VSM method proposed by Rother and Shook [11] proved its usability in production enterprises (see [3, 10, 18]). It allows the finding of potential improvement areas. The power of the tool is also parallel mapping of material flows, control system and information flows. The requirements for the interactions with suppliers and customers (result of Macro VSM) are also incorporated in the local maps. After mapping, the requirements for the production system and supporting processes are defined. Usually the plan of introducing the reengineering process is also elaborated. The VSM is generally dedicated to reengineer the production system and processes, not to develop the IT solutions. However it allows also to depict the main information flows from the perspective of production area. During projects performed in companies [10, 18] VSM proved its usability to create main requirements for company's IT applications, however the information flows and processing are not defined in details.

In consequence the next step (Figure 4) is proposed to perform deeper analysis of information flows. There is several tools to build the complex models of information systems (e.g. IDEF, UML, ARIS, ERD). In author's opinion the promising tool to incorporate in presented approach is ARIS (for more on ARIS methodology see [13, 14]).

ARIS offers several views of built models and is able to cover wide range of analytical areas (information system analysis, quality system modelling, activity based costing [14]). Still research is required to resolve such issues as extracting information flow model from the VSM map and merging this model with other ARIS models (e.g. the models built for office processes).

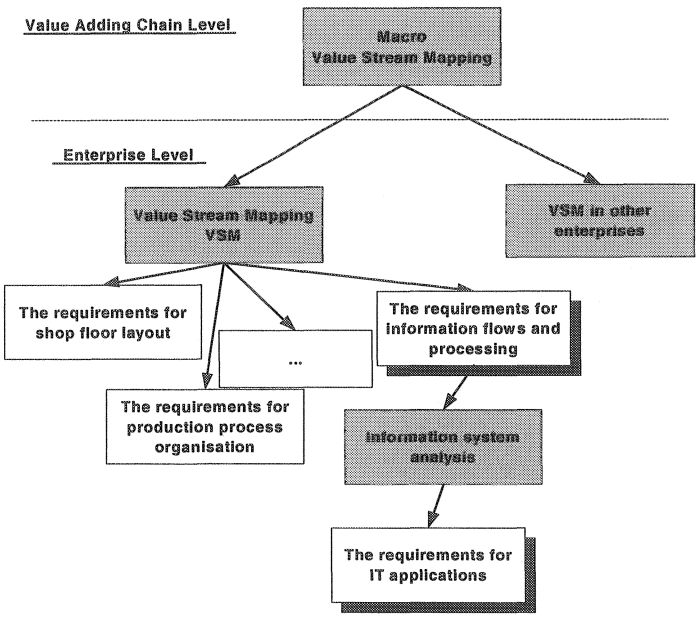

Figure 4 - Implementing new IT applications in "lean" value adding chains

CONCLUSIONS

The "Lean" principles are very applicable to nowadays enterprises and address well the challenges of the current business environment: to lower cost, improve flexibility and maintaining high level of quality. E-business concept gives opportunity to implement "Lean Manufacturing" for the whole value adding chains. Unfortunately the popular IT products such as ERP or SCM systems do not support "Lean" concept. To implement applicable e-solutions for "lean" supply chains the simultaneous analysis of production system (also logistics system) and information flows is needed. The Macro Value Stream Mapping and Value Stream Mapping are key tools. For deeper analysis of the information system ARIS seems to be suitable. In this case research is needed to verify to what extent ARIS can contribute to the presented concept. The proposed approach is matter of research project in CAMT.

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