

# MAPPING OF PROCESSES AS A TOOL OF INDUSTRIAL ENGINEERING

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### ABSTRACT

In terms of companies with complex organizational structure focused on the functioning of various business verticals and interaction of multiple cross-cutting processes, a correct approach to the organization of production is particularly important. Every company that cares about the future of its activities and attraction of revenues, provides continuous control of overhead costs and looks for ways to eliminate them. Among many approaches to improve the production organization the theory of lean production has taken its place in recent years. The concept of lean production requires the involvement of all employees to search for and eliminate losses. In Russia, the concept of lean production is used by such large companies as JSC «KAMAZ», holding company «GAZ», JSC «Sberbank», JSC «Mosenergo» and others. But the tools were developed primarily for typical industrial processes, so they need to be adapted to the implementation at the enterprises where main activities focus on services, e. g. regard-

ing transportation system. The project of lean production in JSC «Russian Railways» is deemed to identify and reduce losses in the implementation of cooperation within the holding company between various departments, as well as external customers. One of the most important instruments of lean production is mapping of production and technological processes. The objective of the authors is to investigate mapping of the processes particularly with regard to JSC «Russian railways», using special mapping technique, comparative method, and general scientific methods. The article describes stages of planning and implementation of mapping and its special transport-related features. The main conclusion is that while implementing mapping to transportation company it ultimately should not be seen as a way to reflect the technological sequence of operations, but as a look at the technology of manufacturing processes from the perspective of the customer, that is, from the point of view of the consumer (internal or external).

**Keywords:** transport, lean production, loss reduction, value for a customer, business value, technology of processes' mapping, map of value stream, operations evaluation parameters.

**Background.** Any manufacturing process may include losses as there are activities, consuming resources, but not creating (not adding) any value for consumers of products. If there are different types of losses every company that cares about the future of its activities and attraction of revenues, provides continuous control of overhead costs and looks for ways to eliminate them.

Among many approaches to improve the production organization the theory of lean production has taken its place in recent years. The concept of lean production requires the involvement of all employees to search for and eliminate losses: only teamwork and common interest can lead to a comprehensive reduction of overhead costs, while also achieving better quality and efficiency of services provided.

In Russia, the concept of lean production is used by such large companies as JSC «KAMAZ», holding company «GAZ», JSC «Sberbank», JSC «Mosenergo», JSC «Russian Railways» and others.

An example is a project of lean production in JSC «Russian Railways»: in the production unit of the holding company the use of lean tools is stimulated, seeking to identify and reduce losses in the implementation of cooperation within the holding company between various departments, as well as external customers.

Lean production has a lot of tools which eliminate losses and increase the value of services provided to clients: 5C, TPM, JIT, kanban, kaizen and others. One of the most important among them, and also used by JSC «Russian Railways» is mapping of production and technological processes.

**Objective.** The objective of the authors is to investigate mapping of the processes in particular in relation to transportation.

**Methods.** The authors use analysis, mapping technique, comparative method, general scientific methods.

### Results.

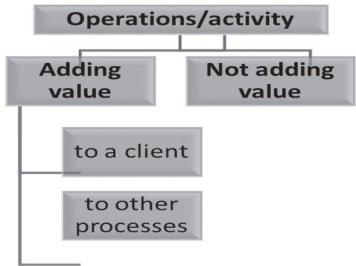
#### 1.

The organizational structure of the holding company «Russian Railways» is formed on the basis of a set of diverse but closely related complexes (business

verticals) and at every management level is riddled with through business processes. Furthermore, all production and technological processes are carried out within the scope of service sector. These two facts led to review a procedure for mapping and develop own approaches to its use in organizations such as JSC «Russian Railways».

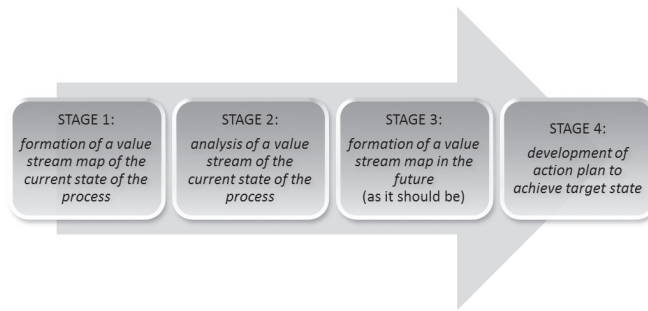
To understand of mapping technology, scope and objectives of its use it is necessary to be aware of the main thing, fundamental concept of the Lean theory. And it is value, i. e. the ability of goods (services) to meet customer expectations. Value is something that the customer is willing to pay for: action, quality, features of a product. The absence of such features is a signal that there are losses. Time to create value is a period during which product / service modifies or acquires properties that are interesting for a customer, that is, it gains value. In JSC «Russian Railways» specifics of the process is that the product / service (the object of labor) ultimately does not change its form / type, but is provided to the client in accordance with required conditions and needs.

Each process can be described (verbally or graphically) in the form of a value creation stream, i. e. a set of actions or operations to provide customers with products/ services (e. g., processes to maintain information system, draw up documents for the carriage of goods, the current uncoupling repair of freight

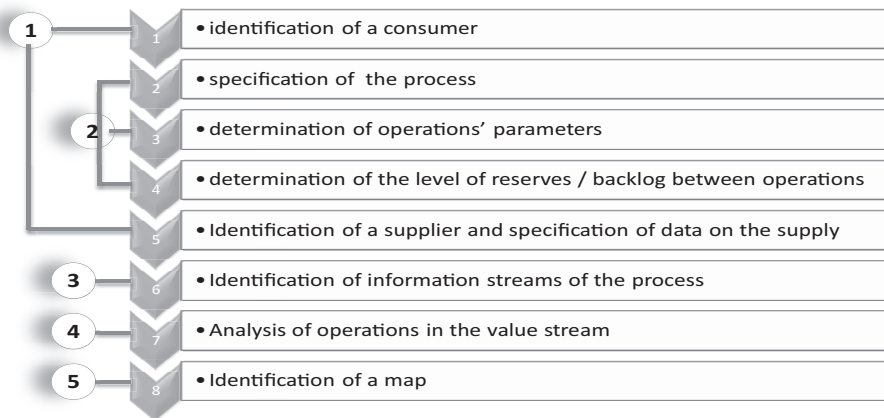


**Fig. 1. Classification of activity/operations in terms of adding value.**





**Pic. 2. Sequence of use of mapping tool.**



**Pic. 3. Classification of stages in building a value stream map**

cars). The detailed description contains the timing combination of materials and information needed to convert the product and / or services on the way to the consumer.

In lean production theory all operations of the analyzed process are divided into two types: adding value to a consumer and not adding value to a consumer. But the practice of mapping has shown that quite often there are situations when it is impossible to unambiguously attribute an operation to one of these two categories. The reason for this is the presence in the provision of services of such subprocesses, operations and activities, which do not have any significance, usefulness for a client, but remain an integral part of the total process.

To avoid such situations, the company Ernst & Young conducted an analysis of mapping technology and proposed a new gradation of operations in terms of adding value. In accordance with the classification a certain activity that from the standpoint of consumers is senseless, for departments, performing it, is necessary and has a value to other processes (the so-called business value). A good example and proof of the existence of business value is financial, accounting, legal work in the IT complex of JSC «Russian Railways».

However, a graphical language of mapping involves determination of only two types of operations (adding and not adding value). Due to this limitation it makes sense to keep two main types of activities in the classification, but to take into account the fact that operations may be useful for both consumers and other internal processes of the company (Pic. 1).

Operations, adding value to a consumer (client, customer) may have the following characteristics:

- are required to meet the requirements of the consumer;
- have a direct dependence of payment on the volume of operations;
- are «critical» activities, without which the process is impossible;
- are activities aimed at creating quality;
- are carried out in accordance with the requirements of the consumer;
- are activities for which, if possible, more time would be allocated.

Operations, not adding value, have opposite characteristics: they are losses that should be eliminated at the stage of analysis. Losses from which it is impossible to get rid of, sometimes include activities with business value to internal processes: these should be minimized. If within the mapping they cannot be minimized, the method of parallelization of operations is applied.

One who is willing to pay for activities or operations that add value to purchased product or service in the theory of lean production is customer (client, consumer). It is he who helps to determine the value – the first stage of mapping technology. In order to more accurately identify the value in any process, you must put yourself in the customer's shoes and try to answer the most basic questions: what does a customer really need?, what is he willing to pay for?

Despite many tips and apparently worked-out technology during analysis of manufacturing processes sometimes it is difficult to identify an end user. This aspect is highly dependent on the degree of refinement of

Table 1

Time parameters to evaluate production operations

Indicators of Lean system	Definition	Indicators in the technology of production organization
Time indicators		
Cycle time (C/T)	Time, required to complete one operation cycle	Duration of one production operation
Tact time (T/T)	Time, set by a customer during which an a performer has to produce a unit of goods or render a particular service	Duration of action repeated many times within the same operation of the process
Changeover time (C/O)	Time to change the operation of the equipment used in the process maintenance	Time of preparation- completion work for maintenance of production processes
Time of value adding (V/A)	Duration of performing all operations, which have value to a consumer	Calculated for the whole process
Lead time (L/T)	Time from receipt of the order to its execution and transfer to the customer	Calculated for the whole process
Labor time (excluding time for breaks)	Available production time, time of one working day excluding dinner, mandatory technical breaks and other stops, provided for by existing rules in the organization	Indicated when the through process is done or controlled by several internal departments / divisions, which have different working hours

action and mapping purposes. When a business unit of the company specializes in providing services with a variety of cross-cutting processes, it is proposed to divide internal and external clients. The transition from the distribution management system in JSC «Russian Railways» to a system of interaction «customer-contractor» and the need to improve horizontal cooperation led to the emergence of internal exchange of services in order to eliminate losses associated with deficiencies in coordinating the efforts of holding structures [1].

II.

In solving enlisted issues a new dilemma occurs: how is a map of the process to be built? What and in what order should be done?

Value stream mapping is a key tool of Lean, which task is to display a visual step by step process to identify losses. But no regulation or other normative documents describe precise limits, rules and sequence of steps for building maps. There is only advice based on the global experience of different companies using this tool in practice.

Before starting any mapping process, it is necessary to realize the ultimate goals of the use of the tool: it influences the script of its application. Various sources of information refer to two main stages:

1) editing of a value stream map of the current state of the process;

2) editing of a value stream map of the future state of the process.

But drawing a value stream map is just a tool: until the process of being analyzed reaches the planned future state, created maps are of little use. Therefore, it is important to distinguish two more stages: analysis and rationalization (Pic. 2).

At the stage № 1 «Editing of a value stream map of the current state of the process it is necessary to study the process in which it is required to identify and eliminate losses, and to build a stream map at the current time in accordance with the rules of mapping. In fact, it is a graphical representation of each element of the process in material and information streams «as it is» from the beginning of the process to the end.

Stage № 2 «The analysis of a value stream of the current state of the process includes:

1) determination of the coefficient of efficiency of the process (Process Cycle Efficiency, PCE), which

is calculated as a percentage of total time of operations, adding value to the overall cost of time (1).

$$K^{EF} = \frac{VA}{L/T} \cdot 100\%. \tag{1}$$

2) identification of losses of the process, which can be eliminated completely.

3) identification of operations, having business value that cannot be eliminated completely, but can be minimized.

The sense of the stage № 3 is that observed losses on the map of the current state of the process must be eliminated and / or minimized, showing these changes in the value stream map of the future (target) state of the process.

Stage № 4 «Development of action plan to achieve target state» is a step by step planning of sequence of real actions required for the transition of the process to a new (target) state without any damage (loss of value) for the consumer. Improvement plan may be, for example, in draft format of lean production (as in JSC «Russian Railways»), in the form of a Gantt chart or some other variant.

The aim of mapping of a value stream process is to achieve a planned future state without losses or with minimum possible value. State of a value stream for a long term or an ideal state («long term future») is considered to be achieved when all possible losses are eliminated and all resources of equipment and personnel are used, as well as the highest customer satisfaction is recorded – for example, production volume, demand satisfaction, delivery cycle.

A value stream map of the process is built in stages. And, as a rule, the most common sequence of stages includes the following list:

1) identification of a consumer;

2) specification of the process (division in operations);

3) determination of operations' parameters;

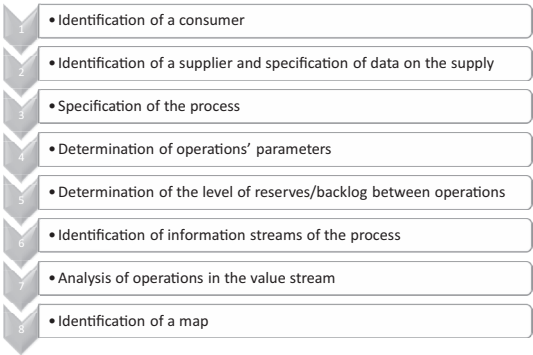
4) determination of the level of reserves / backlog between operations;

5) identification of a supplier and specification of data on the supply;

6) identification of information streams of the process: from a consumer to a supplier;



**Pic. 4. An alternative scenario of building a value stream map.**



**Table 2**

**Quality parameters to evaluate production operations**

Indicators of Lean system	Definition	Indicators in the technology of production organization
Quality indicators		
Defect ratio	Percentage of defects as a result of execution of an order or provision of services	Percentage of errors (technical, technological)
Reliability/ readiness	Percentage of operation capacity of the equipment used in the technological process	Percentage of equipment failure
Number of work shifts	Number of shifts and employees on each shift	Indicated when the through process is done or controlled by several internal departments / divisions, which have different working hours
Executors	Indication of positions of employees performing works on the current operation, or those being responsible for the results of executors	Indicated when employees from different departments or structural units take part in the through process at every stage of the process

**Table 3**

**Parameters to evaluate process operations of the IT-complex**

Indicators of Lean system	Definition	Indicators in the technology of mapping of IT-processes
Cycle time (C/T)	Time, required to complete one operation cycle	Duration of one process operation
Changeover time (C/O)	Time to change the operation program of the equipment used in the process maintenance	Time of preparation- completion work for maintenance of transportation processes, infrastructure complex, IT-processes and systems
Defect ratio	Percentage of defects as a result of execution of an order or provision of services	Percentage of errors (technical, technological)

7) analysis of operations in terms of added value;  
8) identification of a map.

Because this sequence is not fixed in any legal sources, each step can be viewed as a separate, independent unit in building script of a map. Prior to creation of a map it is necessary to make a choice in what sequence it will be formed. To facilitate this task it is proposed to use a method of mapping steps classification in terms of their identity. The method consists of dividing the initial sequence of steps in the blocks – the so-called clusters, in which the stages of mapping are grouped (Pic. 3).

After classification it is possible to choose an alternative scenario of mapping, rearranging, altering steps, first of the first cluster, and then – of the second cluster, and so on (Pic. 4). Editing a new mapping scenario it is necessary to maintain a logical sequence of steps within each formed cluster.

**III.**

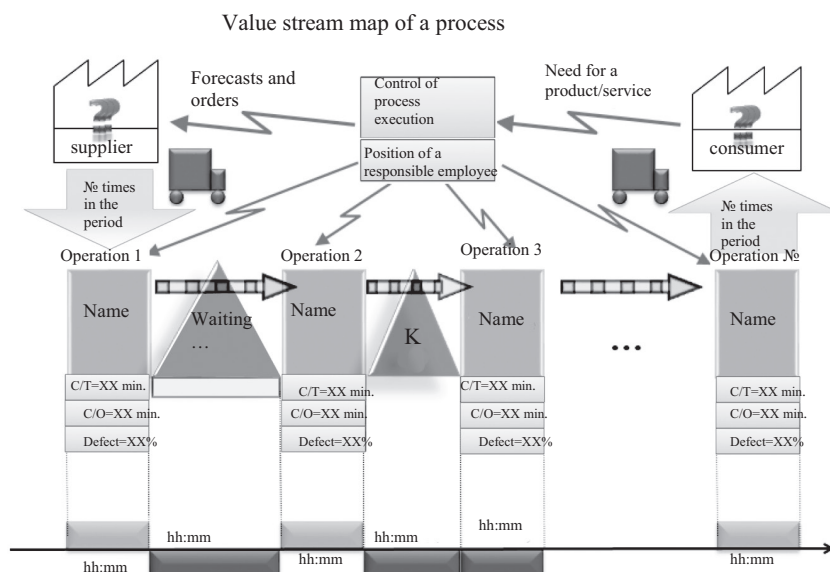
Certainly one of the most important aspects of the process analysis and building of a value stream map

is identification of a consumer, but specification of the process and determination of operations' parameters also require special attention.

The level of specification is selected on the basis of goals and needs of the organization in drafting of lean production project, as well as a type of the process. At the stage of determination of operations' parameters it is necessary to select parameters / opportunities at each stage, that is, for each operation. Indicators are selected in turn, depending on the type of process, the level of specification and mapping purposes. Due to the fact that the use of mapping can be useful to assess usefulness and timing of operations, parameters should be divided into two groups: relating to time (Table 1) and relating to quality (Table 2).

Time characteristics in the mapping process help to determine losses that can be eliminated by reducing the duration of individual operations, not adding value. Quality indicators help to reveal hidden losses: they can be eliminated or minimized by innovative proposals to optimize the process technology.





**Pic. 5. Schematic representation of a value stream map of a process.**

In the mapping of a single process there can also be difficulties with the choice of indicators for operations. This is due to the specifics of the process and its functional purpose. To address the issue, it is advisable to analyze examples of indicators characterizing operations on the value stream map of processes in the IT complex (Table 3), infrastructure business vertical, as well as the provision of services for the transportation activity of JSC «Russian Railways».

In the analysis of the processes that result in manufacturing a final product (goods) it is necessary to indicate the level of reserves / backlog between operations (if any) on the value stream map. But due to the fact that the mapping tool can be used both in the production area, and in the provision of services reserves are not only the amount of material resources, but also time reserves, i. e. waiting time, which is always regarded as a loss. Suboptimal level of interoperation reserves is connected with the lack of synchronization of duration or productivity of operations. This may contribute to:

- misallocation of resources;

- redundancy in complexity of processing;
- losses of properties of materials used in operations;
- untimely making management and operational decisions;
- non-compliance with the terms of the order and customer's requirements.

In the notation of the adopted technology a value stream map of the process looks schematic as it is shown in Pic. 5.

**Conclusion.** Mapping language consists of a set of graphical components, but it is flexible enough: the use of all elements is not necessary, it is important to display on the map only the main elements that help to identify and potentially eliminate the overhead costs of the company.

Mapping ultimately should not be seen as a way to reflect the technological sequence of operations, but as a look at the technology of manufacturing processes from the perspective of the customer, that is, from the point of view of the consumer (internal or external), whose priority is to eliminate losses and achieve desired results within each process or from each service.

## REFERENCES

1. Verbov, D.M., Efimova, O.V., Baboshin, E.B., Kalinina, D.V., Igonnikov, B. V. Efficiency of lean production projects to reduce losses at the stations [*Effektivnost' proektov berezhlivogo proizvodstva po sokrashheniju poter' na stancijah*]. *Bulletin of OUS JSC «Russian Railways»* [Bjulleten' OUS OAO «RZhD»], 2013, Iss.4, p. 37.
2. Womack, James P., Jones, Daniel T. Lean Thinking: Banish Waste and Create Wealth in Your Corporation [Translated from English]. 6th ed. Moscow, Alpina Publisher, 2011, 472 p.
3. Liker, Jeffrey K. The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer [Translated from English]. 6th ed. Moscow, Alpina Publisher, 2011, 400 p.
4. Zamyshliaev, A. M. Results of Implementation of the Project of Integrated Management of Resources, Risks, Reliability Analysis at all the Stages of Life-Cycle (URRAN). *World of Transport and Transportation*, 2013, Vol.11, Iss. 1, pp.100–109.

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