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Reengineering Organizations in Integrated Transport Management Systems

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Abstract:

Purpose: *The article sequentially presents elements of technological development in transportation and organization reengineering.*
Design/Methodology/Approach: *The article aims to analyse integrated transport systems, with an emphasis on their integration as a part of reengineering transport needs, and to develop data flow models. Accordingly, the following research problem was formulated: Should structural business modelling techniques be subject to organization reengineering and teaching for future transport managers? Obtaining answers to the above questions required the application of qualitative methods. The synthesis method and literature analysis were used for research purposes.*
Findings: *It characterizes Data Flow Diagram (DFD) models and describes the stages of DFD modelling. It was stated that the indicated techniques can be used both for the analysis of an existing system, to determine its functions, effectiveness, and efficiency, as well as for collecting, describing, and modelling functions and data for a newly implemented system.*
Practical Implications: *Reengineering can be used to support the activities of transport managers by providing timely, competition- and distortion-proof information representing an appropriate level of information, as well as defending against various types of threats.*
Originality/Value: *A dynamically changing environment, progressing globalization, increasing intensity of competition, and threats of crisis phenomena require the development, improvement, and implementation of innovative management systems. The challenge lies in skilfully selecting and implementing a management concept that is closely related to the company's tradition, current state of enterprise, and external factors resulting from the system's environment.*

Keywords: *Organization, reengineering, system, technologies, transport, management.*

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1. Introduction

An Integrated Transportation Management System (TMS) allows for the better management of logistics and transportation in companies that aim for high supply chain visibility. Such an IT solution not only provides companies with modern technologies but also, through integration with other systems, increases work efficiency.

In this article, we will discuss what an integrated transportation management system is and try to determine the key benefits of integrating TMS systems with WMS. A TMS (Transportation Management System) is an integrated transportation system used for managing transportation and logistics within a company.

TMS enables the monitoring and coordination of all transportation-related processes, from order acceptance to the delivery of goods to the customer.

TMS functions include route planning, information flow management, shipment tracking, transportation cost analysis, and warehouse and inventory management. Through TMS, companies can optimize their logistics processes, increase operational efficiency, and reduce transportation costs.

TMS is typically software that integrates with other systems within the company, such as ERP (Enterprise Resource Planning) or the WMS (Warehouse Management System). As a result, TMS can act as a logistics hub and coordinate the work of different systems, leading to better action synchronization and greater overall efficiency of the company. Thus, TMS:

- Enables transportation companies to plan routes and schedules, monitor vehicle fleets, manage document flow, and coordinate transportation-related activities;
- Helps transportation companies save time and money by optimizing routes and utilizing available transportation resources more efficiently;
- Assists transportation companies in meeting regulatory requirements, such as driver working hours and road safety regulations;
- Integrates with other systems, such as Warehouse Management Systems (WMS), Order Management Systems (OMS), and Enterprise Resource Planning (ERP) systems, enabling comprehensive supply chain management;
- Improves communication between different departments of the company, such as transportation planning, distribution, sales, and customer service, contributing to better coordination and increased efficiency;
- Provides better visibility and control over the flow of goods and information, enabling a quick response to changing market conditions and customer needs.

An Integrated Transportation Management System (TMS) with Warehouse Management System (WMS) software enables comprehensive supply chain management, from gathering goods in the warehouse to delivering them to the customer. Here are some benefits that integration can bring:

- Better synchronization of activities between departments dealing with warehousing and transportation planning.
- Improved visibility of the entire supply chain, allowing for a quick response to changes and a reduction of the risk associated with product unavailability.
- Process optimization leading to increased efficiency and cost reduction.
- Enhanced customer service leading to increased satisfaction and loyalty.
- Improved data analysis regarding the supply chain, enabling more accurate business decisions and improving overall process efficiency.

2. Elements of Technological Development in Transportation

There is no need to remind ourselves of the tremendous impact that science, engineering, and technology have had on the economy (Białko, 2005). Let us instead recall their definitions:

Science - is an intellectual activity that allows for precise statements subject to proof or verification. Science creates theories necessary for the development of engineering and technology, striving to understand the real world: space, matter, and energy. Science is part of our cultural heritage. It has had a tremendous influence on our worldview and the place we occupy in it.

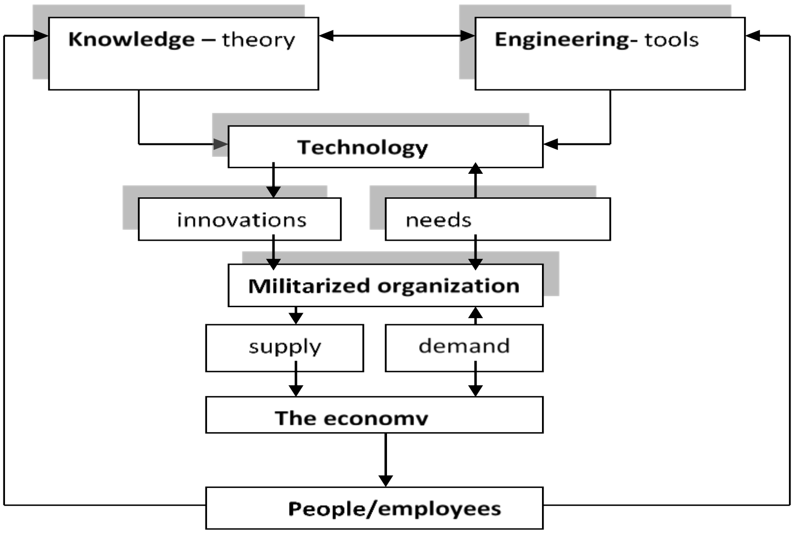
Engineering - is the art of directing the forces of nature for the benefit and convenience of humans. It utilizes natural phenomena discovered by scientists and formulated in theory for practical, economic purposes. Engineering provides the tools necessary for the development of both science and technology; it serves as a "translator" between science and technology.

Technology - is systematic knowledge and action in industrial processes allowing for the attainment of desired objectives. It concerns tools and techniques, the processes of plan execution (Wawrzyniak, 2001). By technology, we mean general ways of realization, e.g., products, devices, or objects, including transportation.

Technologies define sets of basic components utilized in them, and then sets of corresponding operations that must be performed on these components to obtain the desired product or object. Technology represents the transformation of knowledge and tools into social benefit. This description can be further detailed by demonstrating the relationships and feedback existing between the entities of technological development (Chmielarz, 1996), as depicted in Figure 1. Without ensuring the three key elements of civilizational progress: the development of science, technology, and innovation, it will not be possible to build a knowledge-based economy.

From the perspective of a transportation organization, the fundamental issue is not knowledge itself but its application in practice.

Figure 1. *Participants in technological development, improving the functioning of transportation*



Source: *Own elaboration based on Doug, (2017).*

New technologies are primarily a factor in economic development. But science, knowledge, and technology are also necessary for the proper functioning of society, for its prosperity. In the activities of the United Nations Development Programme, new technologies become a powerful tool for social development (Grabowska, 2015). Social development and technological development can mutually reinforce each other.

This happens to a significant extent through education and skill development, which are necessary for the effective use of technology, especially in economic systems, and particularly transportation systems, without which the economy has no chance of functioning. The benefits of reorganizing business processes using new technologies play a significant role in improving organizational performance in terms of costs, quality, deliveries, employee efficiency, and transportation organization by:

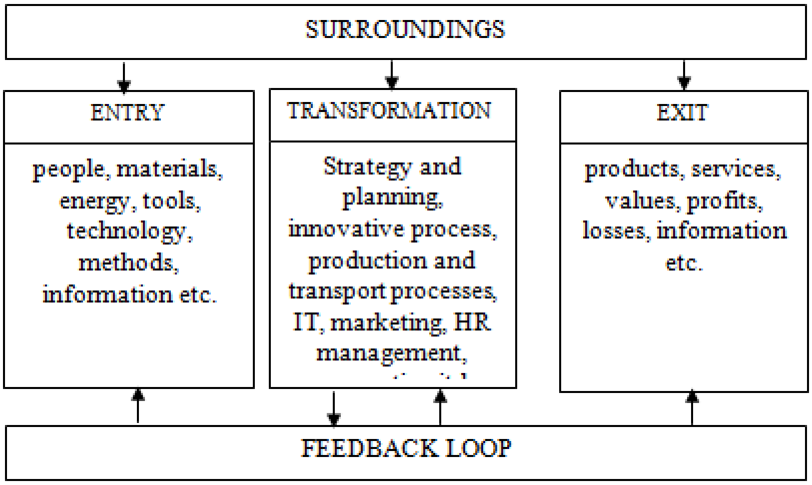
- Streamlining business processes and systems,
- Easily adapting to changing times and reducing operational costs,

- Increasing company profitability and maintaining a competitive edge,
- Increasing employee productivity,
- Increasing customer satisfaction by improving the quality of products and services.

2.1 Organization Reengineering

The development of organization and management theories, especially their IT support, encompasses several different directions and concepts, with the most important being the systemic approach. The basic principle of this approach is to treat every economic organization as a system (Figure 2).

Figure 2. *Organization reengineering*



Source: *Own elaboration based on Kobza (2002).*

Economic organizations engaged in transportation activities are a system (Kopczewski, 2001):

- open, engaging in constant exchange of energy, matter, and information with the environment,
- artificial and natural,
- organized into socio-technical systems,
- hierarchical in structure,
- capable of self-improvement.

However, the fundamental paradigm of the systemic approach should always be the holistic treatment of the organization, i.e., not as a sum of elements but as a new quality, presented in its entirety, with its internal structure. Therefore, regardless of the design of organizational structures, the fundamental element of its functioning is organization reengineering - the technical reorganization of action processes (BPR - Business Process Reengineering) - a philosophy aimed at introducing improvements (Kopczewski, 2004).

Reengineering is an approach based on radical changes in strategy and the use of modern technology. Implementing this method in an enterprise affects its mode of operation and often improves its results. A decisive advantage of this concept is its high flexibility and the possibility of application to both a single process and the entire scope of enterprise activities.

The application of reengineering to processes in a transportation company is a very interesting but also challenging solution, the process of which may allow for (Kopczewski, 2008): reducing the tasks performed in the process, eliminating the need for employees to engage in monotonous tasks, improving process efficiency, eliminating errors made by employees that resulted in mechanical damage to transportation products, reducing production costs. Its goal is to achieve gradual improvement in activity results through technical reorganization of processes essential to the organization's functioning, maximizing added value, and minimizing all unnecessary elements.

Designing a reengineering system requires the use of various structural techniques for system design. One of these, perhaps the most important, is process modelling in the system (functional structure) using diagrams (data flow techniques).

3. Models of Data flow-Data Flow Diagram (DFD)

They illustrate the interdependencies of functions by defining the flow of data between them and serve to present the process model in the system, as well as the relationships between data and processes, the flow of data between processes in the system, and the external world and the system. DFDs present the system at any level of detail. To describe it, the following elements are used (Kopczewski, 2006):

- external objects (terminators, external entities, external entities) - represent sources and destinations of information external to the analysed system (those that provide and receive data): CUSTOMER, SUPPLIER, RECIPIENT, BANK, and others;
- data repositories (warehouses, collections, data stores) - represent places for storing data between processes (only accessible from processes). The existence of a repository in DFD makes sense when the data stored there serve the implementation of at least two processes (Kobza, 2002): all kinds of FILES;
- processes (functions, processes) - define the way of performing one or more functions: program, procedure, algorithm, manual or automated operation (completely or partially) - all activities performed on data;

- data flows (streams, data flows) - represent the circulation of data in the system: links between processes and other DFD elements.

Diagram building - process decomposition is most often carried out hierarchically. The well-known psychology principle of 7 + 2 is applied here, indicating that the average human perception allows for understanding a whole consisting of such a number of elements and relationships between them. In relation to DFD, this principle means placing a maximum of about seven processes and associated data flows, stores, and terminators on one diagram. The decomposition process proceeds hierarchically, starting from the context diagram to the specification of elementary functions, further to non-decomposable ones.

Developing a context diagram becomes the basis for a zero diagram, also called a systemic one. It allows starting the process of extracting diagrams at lower levels of the hierarchy down to the specification of elementary processes. An important aspect of decomposition is maintaining a uniform hierarchy process symbolism.

Here, a decimal code is used, initiated by process codes in the systemic diagram. It is worth noting that if 7 processes were extracted at each level, starting from zero, there would be 49 on the first level, 343 on the second, 2401 on the third, etc., (Michalski, 2005).

With such a number of processes, the global data flow diagram would already become unreadable for anyone. Decomposition is thus a tool for mastering the complexity of the system and its description. The degree of system complexity is diverse and can be measured to some extent by the number of levels in the decomposition hierarchy (excluding the context level). Thus (Michalski, 2005):

- A simple system counts from 2 to 3 levels.
- A moderately complex system has 3 to 6 levels.
- A complex system has 6 to 8 levels.

If individual hierarchical decomposition paths are developed in a given DFD to different extents, one can speak of its skewness. Taking into account the degree of detail of the diagrams, context and zero (systemic) diagrams are used.

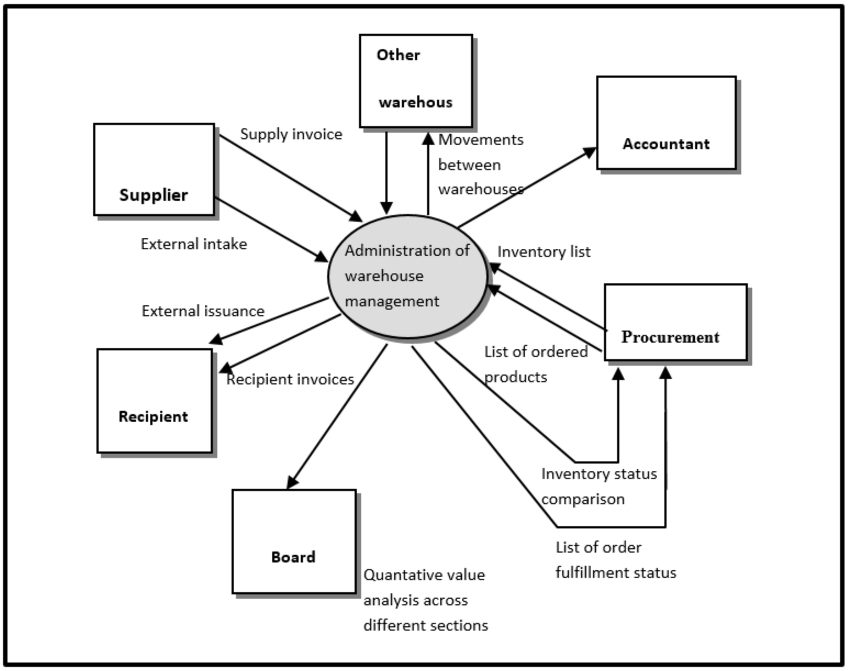
3.1 Context Diagram

Figure 3 defines the scope and boundaries of the system, and presents the connections of the system with its environment, i.e., the context in which the system operates. The system is presented as a single process. Terminators are depicted on its perimeter, and in special cases, external data stores, directly linked by data flows. During the creation of the context diagram, the following activities are performed (Polonka, 1994):

- presenting the system as a single process;
- establishing, together with users familiar with the specifics of the subject domain, a list of basic events - queries (input operations) and related responses (output operations); they constitute data flows binding the system with the environment;
- determining the sources and destinations of data - these are terminators and external data stores.

The precise execution of these activities allows for the development of a contextual diagram, understandable for the management of the transportation company and serving as the starting point for the decomposition process in the form of a DFD hierarchy. The prepared diagram serves as a kind of "territory map" of the subject domain.

Figure 3. *Contextual diagram of the transportation system process*



Source: *Own elaboration based on research, additionally (Polonka, 1994).*

3.2 Zero Diagram

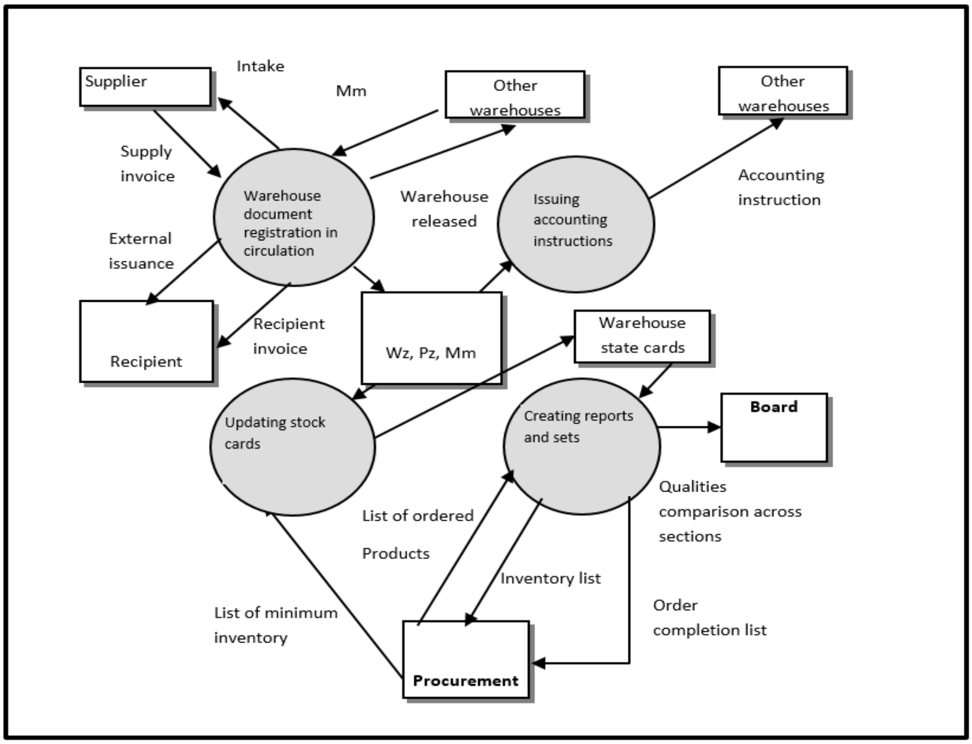
The decomposition of the process in the contextual diagram begins with the creation of a zero diagram (also called systemic), which directly derives from the contextual diagram. The crucial aspect here is the decomposition of the single process from the contextual diagram into several processes.

These processes are further decomposed aggregates down to elementary functions. At the zero level, internal data stores are also introduced, and terminators are transferred from the contextual diagram. Processes, data stores, and terminators are linked with data flows from the contextual diagram. Figure 4 is an example of a zero diagram resulting from the contextual diagram presented in Figure 3.

3.3 Detailed DFD

DFD presents a precise picture of processes and subsystems. During the decomposition of diagrams, the principle applies that only data flows that appeared at the zero level can occur at lower levels of the hierarchy. DFDs can be used to present the system concept and then, by detailing, to present the entire system and its modules. Through the analysis of successive processes and sets of data and the adjustment of data flows, the model becomes more detailed, providing a more precise description of the system's dynamics.

Figure 4. *Zero diagram of the transportation system process*



Source: *Own elaboration based on research, additionally (Polonka, 1994).*

3.3.1 Stages of DFD Modelling

These stages involve determining (Kopczewski, 2004) in sequence:

- the main process (which will be detailed);
- processes constituting the main process;
- data stores;
- flows between processes and stores and external objects.

Regardless of the level of detail in DFD, the following principles apply to their creation:

- capturing main processes and detailing them is more appropriate than generalizing elementary processes;
- assigning clear names to processes, flows, stores, and entities;
- ensuring that no data unused by a process affects it;
- ensuring that each data flow originates from or ends at a process;
- consistently using symbols and marking repeating elements appropriately;
- ensuring internal consistency and consistency with other related DFDs; verifying DFDs.

The most important practical guidelines for structural analysis and design of information systems using data flow diagrams can be summarized as follows (Kopczewski, 2004):

- Data flow diagrams are organized in a hierarchy: context diagram, zero diagram (systemic), elementary processes.
- Diagrams allow for the description of systems of varying complexity:

  - simple system: 2 to 3 levels;
  - moderately complex system: 2 to 5 levels;
  - complex system - above 5 levels.

- ✓ The diagram cannot exceed the size of A4 format.
- ✓ The decomposition of processes follows the 7+2 principle.
- ✓ All categories appearing at level n-1 must be shown at level n (also in decomposed form).

Category names in a given hierarchy of diagrams are unique.

- Flow names to and from data stores are not assigned.
- Flows between stores and between terminators are not allowed.
- A store must be used by at least two processes.
- Procedures for start and end, loops, decision blocks, identical process and flow names are not allowed.
- An arrow to a data store signifies specific changes (input, update, deletion).
- An arrow from a data store signifies that data are read.

- The diagram includes both manual and automated processes.

The data flow method emphasizes functions greatly but pays little attention to data structure and collection. In analytical and design work, a more detailed description of entity attributes and database structures is necessary. Data modelling, presenting their structure and defining relationships between entities and attributes essential for system functioning, is a significant element of analysis and design.

For this purpose, Entity-Relationship Diagrams (ERD), which illustrate the static structure of the system (Sroka, 2005), are used. Entity-relationship diagrams transform the real world into sets of entities and the relationships between them. They are widely used in database design, especially in analysing functional dependencies, addressing problems related to data redundancy, and organizing database structure.

This technique is also used in software design and specification not only in the database design phase but also in designing and analysing individual software modules.

3.3.2 Control and Verification of Process and Data Models

The prepared models of functions, processes, and data must be verified and checked for correctness, completeness, and consistency. To obtain a coherent and complete system model, strict integration of data modelling, function and process modelling, and strict synchronization of process, flow, store, and entity descriptions is recommended.

This is a particularly difficult task in the entire process of building a model of an existing or planned system. Computer-aided software engineering CASE tools facilitate such synchronization. All models defined in the analysis phase must also be mandatory verified by the future system user. This verification usually takes place in several stages, and each subsequent iteration brings us closer to a model that correctly describes the real or planned system.

4. Discussion

The indicated techniques can be used both to analyse an existing system, to determine its functions, efficiency, and effectiveness, as well as to collect, describe, and model functions and data for a newly implemented system. They allow for the completion of the analysis with a detailed specification of the existing or planned system. Such a specification has the following characteristics (Wawrzyniak, 2001; Sutton and Pleffer, 2002; Wrycza, 1999),

- it enables easy familiarization with both general and very detailed information about the system,

- it is easy to maintain and modify,
- it is readable as it is based on graphical notation,
- it presents the system at various levels of detail, making it understandable for analysts, designers, and users, as it focuses on the logical aspects of the system,
- it is independent of future technological solutions,
- it is concise and precise.

The results of the analysis and modelling presented allow us to prove the thesis that structural business modelling techniques should be the subject of organizational reengineering and teaching for future transportation managers. The resulting process optimization should follow the following procedure, steps:

Step 1: Determining a business goal vision. This makes it easier to understand the need for changes and create a clear vision of where the company should be in the future. Then, it is necessary to specify the goals both qualitatively and quantitatively.

Step 2: Establishing a competent team. The selected team must be multifunctional because knowledge and perception from all levels of the organization are necessary to minimize the chances of failure. It is the duty of top management to have a clear vision of the actions to be taken and to provide strategic direction.

An operational manager who knows the secrets of processes is needed. Equally important is to have appropriate engineers with different experiences from different fields to complete the team. At this stage, it is important that goals and strategies are properly outlined.

Step 3: Understanding the current process. In this step, select the process(es) to be redesigned. Processes that are faulty, multifunctional, value-adding, have bottlenecks, or have a significant impact on the organization can be prioritized. Once selected, map them using flowcharts or process maps to carefully analyse them to identify gaps, inefficiencies, etc.

Step 4: Redesigning the process. Keeping the vision in mind, redesign the new process that effectively overcomes the inefficiencies of the previous process. Here, you will create a future state map that highlights the solutions identified for the problems in the current state process.

Step 5: Implementing the redesigned process. After redesigning the process, a small test can be conducted to see how it works by monitoring it using the processes defined earlier. This will allow for necessary adjustments to the process before implementing it throughout the company. If the new process performs better than the previous one, it can be implemented on a larger scale.

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