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INTEGRATING PORT EQUIPMENT MAINTENANCE PROCESS INTO PORT MANAGEMENT INFORMATION SYSTEM (PMIS)

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Abstract. *The maintenance process in ports encompasses preventive, corrective and combined maintenance of all types of equipment used for performing work processes (reloading, transport, weighing, warehousing). The equipment is exposed to various potentially harmful effects, which results in malfunctions and the need to maintain the system. The paper shows research on the analysis and the reengineering of the maintenance process for the river port information system implementation and the integration with other port processes.*
Key words: *Maintenance process, Port management information system*

1. INTRODUCTION

River ports provide many services which can include unloading of goods from the vessels, storing the goods at the appropriate space such as open or closed warehouses, and loading of goods to the other means of transport such as trucks or railway. River ports can also provide measuring services and mooring services for vessels. In order to fulfill all the planned activities, ports must be provided with adequate equipment. Maintenance of equipment presents very important activity in the process of providing transloading services in river ports. Most of transloading equipment present cranes, forklifts, wheel loaders etc. Also, in order to successfully manage all port operations, it is important to manage all the created information and that can be done with the application of the port management information system (PMIS). Additionally, the port management information system can be connected to other types of information systems such as geographic information systems (GIS) and to various web applications made for supply chain management (SCM). This enables that all the activities are executed in a timely manner. To fully implement port management information system, port processes have to be changed in the terms of changing or adding information which is needed for successful and accurate execution of port operations. This paper presents a model for port equipment maintenance process which is created prior to earlier process analysis. Section 2 presents overview of maintenance management. Section 3 presents case study of river port equipment maintenance and process modeling for the integration into PMIS. Section 4 presents conclusions and future work recommendations.

2. MAINTENANCE MANAGEMENT

Equipment maintenance management presents important support process in industrial and service enterprises. It presents safety feature for many work systems, as it is important to identify critical equipment and maintain it regularly, to make it available and reliable during its operational time [10]. To automate the maintenance management process it is necessary to do three main activities [6]:

- collecting information about equipment,
- processing information and
- making maintenance decisions.

Different technologies can be used to collect information about equipment condition, such as radio-frequency identification (RFID), hand-held computers and smart-phones [7]. This information includes various information like equipment location, inventory number, manufacturer data, production date, equipment type, weight, energy consumption data and equipment current condition data. The collected data is worthless if it is not managed properly through appropriate software support. Acquired information management means data storage and retrieval, data processing and distribution. Most of the software applications for maintenance process integration and management utilize internet and web platforms [2]. Before the implementation through the information system, it is important to define all the activities through process model. Through process definition the maintenance activities and information flows are defined. This provides a basis for resolving different decisions that have to be made. Examples of maintenance process

analysis, design and integration can be found in [4], [8] and [1].

The case study presents the port of Novi Sad and the port management information system. It is presented how the existing port services are integrated with other systems and participants in the supply chain. It is also presented how the equipment maintenance process is reengineered to be ready for integration into PMIS.

3. CASE STUDY - RIVER PORT AND PMIS

The port of Novi Sad is located on the left bank of the Danube river, at 1254. kilometer, on a total area of 350000 m^2. Quay length is 800 meters. The port has four anchorages. Port is connected to the railway. The port handles and stores [9] :

- bulk cargo,
- general cargo,
- containers and
- liquid cargo.

The port disposes with the following equipment [9]:

- 5 portal cranes, capacity 5t to 27.5t,
- 7 forklifts with a capacity of 3t, 1 forklift with a capacity of 5t, 2 forklifts with a capacity of 12.5t, 1 forklift with a capacity of 28 t,
- 2 wheel loaders, 3 skid steer loaders,
- 2 weighbridges, of which one is for road and rail with a measuring range of 100t,
- 2 telescopic funnels for bulk cargo handling, capacity up to 500 t/h per funnel,
- 2 packaging machines (packing of bags of 50kg and big bags of 1 000 kg),
- Pump for oil products with a storage capacity of 270000 m^3.

The port management information system PMIS presents integrated system which facilitates planning, execution, control and management of the business processes in the port. The PMIS provides the information and data in real time related to the movement of vessels (entering the port, activities in the port, exiting the port), weighing and warehousing processes and transloading service provision. PMIS also provides data management about business partners, financial transactions, human resources and existing equipment. The model of PMIS was developed using the information and knowledge gained during the work on the EU project DaHar [3], in the segment related to the development of River Information Services (RIS) [11]. The requirements set by the employees of the port have also been taken into account. PMIS present combination of interconnected components, which collect, process, store and distribute the information needed for decision making, coordination and process management at the port. PMIS provides its users with real-time information about vessels' entry and exit from the port, equipment management at the port, logistics information, financial and accounting updates. PMIS can be connected to other systems and participants in the supply chain. The integration model is presented in Figure 1. The aim of creating the river port model and application software is to raise competitiveness by increasing the efficiency of using the work systems in the port, increasing customers' satisfaction and the quality of services provided. The PMIS enables integration of port business processes, as well as external integrations with the RIS and other systems, which should create the following positive effects:

- improved data correctness,
- real-time data provision,
- decreasing the scope of manually processed data and the number of mistakes in data,
- information exchange control,
- improvement in the quality of decision-making and customer service.

Figure 2 shows which port processes integrate through PMIS.

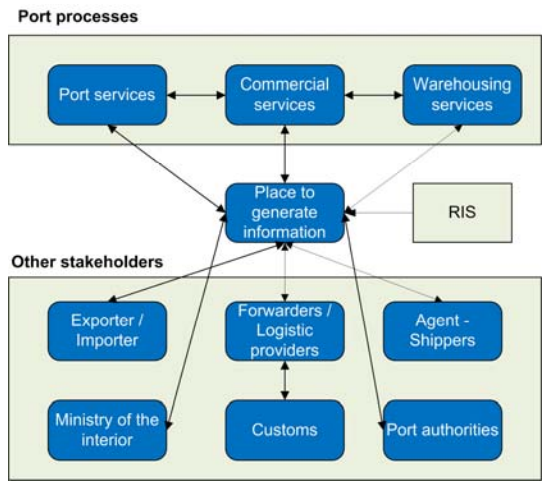

Figure 1. Integration model [5]

Analysis and reengineering equipment maintenance process for PMIS integration

The application of IT solutions in the equipment maintenance management is at the lower level compared to other processes in the port. The process analysis showed that the activities workflow isn't structured or systematically defined. Records and documents are generated manually and are incomplete and not up-to-date. There is a lack of certain activities necessary to implement the maintenance management process. The existing state and solutions applied in advanced business systems serve as the basis for setting up a new model of maintenance process, in order to be ready for the PMIS support. Having in mind the types and specific features of the equipment used for the port services provision, the following basic structure of the maintenance process has been defined:

- creating basic maintenance code lists,
- maintenance of equipment:
  - reporting malfunctions,

- preparation for intervention,
- maintenance procedure implementation,
- reports processing and analysis.

Maintenance code lists creation

This process should facilitate updates of basic internal information about the factors important in the maintenance process. It has been designed to facilitate the application of a unique labeling system (identification and classification) of the tools and machines. The concept of the unique catalogue facilitates unambiguous identification of factors (each factor has an identification number or label). The classification enables the factors to be put into groups and subgroups, according to certain characteristics that facilitate grouping for the purpose of executing other processes. The tools and equipment are classified using the catalogue of tools and equipment. The locations of malfunctions can also be classified, so that the reports and reviews could group and sort the information. The causes of malfunctions are classified according to the code list presented in the detailed project.

Basic-internal catalogue of tools and machines encompasses the information about the equipment used for reloading, such as cranes, two loading hoppers, loaders, mini-loaders, fork-lifters (3-12.5t), tractors, trailers, passenger vehicles. The internal catalogue of tools and equipment contains information about the tools and equipment listed in the *Tool and Equipment Record.*

Reporting malfunctions

The foreman or the operator of the tool/machines which experienced the malfunction is obliged to report it. It is done by filling in a *Malfunction identification notice.* The reported malfunctions are recorded (by the on-duty employee) for the head of the maintenance department in the *Maintenance log.* The decision regarding the need to address the malfunction is made by a manager.

Preparation for intervention

The preparation for intervention is conducted by the head of the maintenance department. The procedure is based on the type of *malfunction,* i.e. *information about the malfunction* and the analysis of the documentation regarding the equipment. The preparation of the additional maintenance interventions encompasses the following activities:

- entering the description of the activity into the *Maintenance order form,*
- completing *Procurement need form*, based on the information entered in the order form, so that material and spare parts could be taken from the warehouse,
- processing *Service order form*, for commissioning other organisations for the works on removing the reported malfunction.

Maintenance procedure implementation

Those in charge of performing the procedure leave for the location and follow the description listed in the *order*. After the malfunction has been removed, the head of maintenance department is informed, and the unused material and spare parts are returned to the warehouse and the *Spare part return form* is created and processed. If the activity has been performed by an external organization, the head of maintenance signs the *Report on the performed service*. The interventions are recorded in:

- *Maintenance log*, entering the time when the activity was finished,
- *Tool and equipment card*, information about the changes to the equipment following the maintenance activities.

The signed and approved orders, with supporting procurement forms and return forms are submitted to the accounting department.

Reports processing and analysis

Based on the conducted analyses and recorded interventions, the head of the maintenance department creates reports on performed activities on removing malfunctions:

- Report on malfunction,
- Report on causes of malfunction,
- Report on used material and spare parts,
- Suggestions for remedial measures,
- Damage report.

The reports are created using the templates provided in the detailed project document.

IDEF0 maintenance process model

For process modeling the IDEF0 method is chosen. IDEF0 model is shown in Figure 3, according to the previously conducted analysis and suggestions for introducing and improving the maintenance process. With all the activities and all information and material flows defined, the integration of port equipment maintenance process into PMIS is enabled.

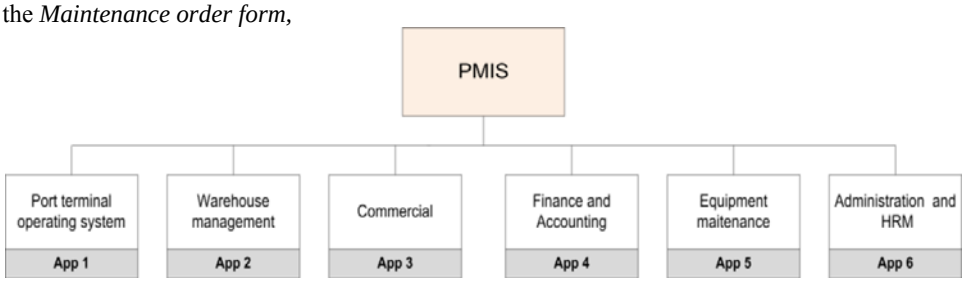

Figure 2. PMIS integration structure for port processes

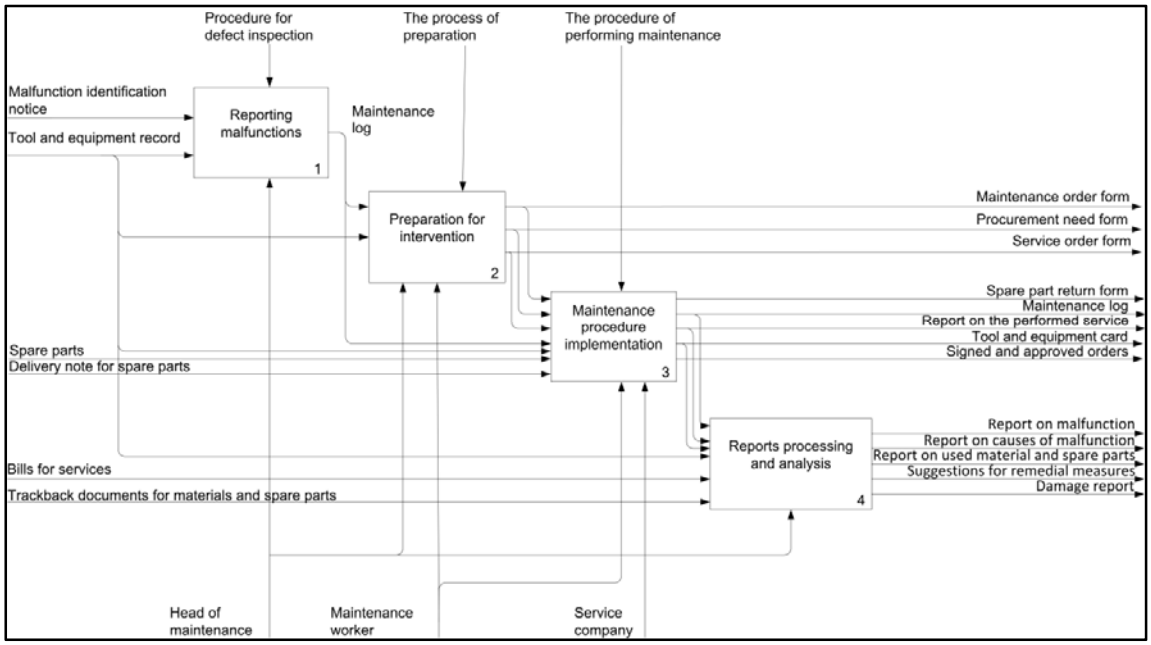

Figure 3. Maintenance process IDEF0 model

4. CONCLUSIONS

The research presented in this paper presented process analysis for maintenance of port equipment. The created process model gave focus on all the necessary activities and flows. Future research work should encompass the implementation of RFID technology to automatic detection of the equipment state.

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