MANAGEMENT INFORMATION SYSTEMS IN POLISH RAILWAY TRANSPORT IN THE CONTEXT OF THE TECHNOLOGICAL AND THE ORGANIZATIONAL CHANGES

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Paper presents the implementation problems of information management systems in the railway industry with an analysis of the current situation, the needs of companies and benefits of the implementation. It takes into account the area of financial management, a range similar to the other companies, as well as the area of operational management specific for their activities. These issues are presented in the context of technological changes taking place since the beginning of the XXI century in the information management systems and organizational changes in the PKP Group with the transport operations and railway infrastructure management separation, consolidation of the PKP Group and the changes connected with the preparation for the privatization of some of the group entities.

Keywords: information management systems, railway industry, PKP Group, information technology

1. Introduction

This paper presents the historical, technological and industrial conditions of management systems in the Polish State Railways. Even during the communist regime (which was not the best time in the management of business organizations) in the absence of now widely available and necessary tools it was possible to suc-

cessfully implement systems supporting management processes. Thay allowed not optimal, but effective management of a giant enterprise, which were Polish State Railways. Selected whole railway network systems implemented in the first decade of transition before the embargo on information technology has been canceled are presented. Also systems implemented and deployed after 2001 in PKP Group companies are shortly described. Moreover the changes in the PKP Group and challenges in the area of management systems are pointed out. The factors that allows effective and long-term operations of the management systems, on the example of material management system GOSMAT are indicated in the summary.

2. Historical, technological and industry conditions of the management systems implementation in the polish railways

Railways as a great and complicated organization operating throughout the country always had high demands, therefore management systems became very early on. IT Department of the Polish State Railways (PKP) comes from the Central Statistics Office established on 1 January 1958. It implemented statistical calculations using the tabulating machines. The results were used in the assessment of the economic situation and in making management decision. In 1962 Central Statistics Office has been transformed into the Central Office of Mechanization and Automation of Statistical Calculations (COZO) which was directly under the Ministry of Communication. At the same time Bull series 300 MCT machines were introduced into operation. Those machines formed a connection between analytical machines and electronic computers. Computers appeared in the 1960s. in the form of ICL series 1900 machines and then ODRA series 1300 machines manufactured under license by the Wroclaw factory ELWRO. These computers in subsequent versions PKP bought at the beginning of the 1980s. Some of them had been used until the beginning of the 21st century. In 1976 COZO (with subordinated to it centers in Warsaw, Łódź, Sosnowiec, and Olsztyn) was transformed into Central Information Technology Office of Railways (COIK). Then the Management System Design and the Control System Design Services have been created in the COIK and processes of modern business management systems development and operational management of rail traffic systems have been launched. In addition to the COIK organizational structures between 1974 and 1979 in the Regional Directorates of Polish State Railways had been created Regional IT Centers [1].

When the 3rd generation computers had been implemented the whole railway network systems corresponding to the most important challenges of enterprise management have been developing and implementing. Until 1980s PKP management systems like in the majority of other companies were autonomic and scattered as in the general management area called for the purposes of this article *back office*

area as well as in the operational management area called *front office area*. Dispersal and diversification stemmed from technical and organizational reasons. Technical reasons were the lack of computer networks. Only local terminals and telexes with limited bandwidth were available. In addition to the central structure of the COIK Polish State Railways company had its own Regional IT Centers, which in a number of ways were responding to the demands in the management systems area. Their tasks had not been properly coordinated. The effect was that they developed different systems solving similar problems but experiences in solving the problems could not be used by others. Different business units had used different technical solutions and tools. This situation lasted until 1992, when the Information Technology Department of Polish State Railways was created and Regional IT Centers started working in that structure. Main tasks of the Information Technology Department were: designing, implementing and operating of traffic management system and financial management system (SKPZ – system), organization and coordination of the other IT applications, agreeing IT applications projects of organizational units, coordination of statistics issues, the methodology and standards development for the information systems [1].

Back office systems should not be different from those used in other businesses. The specificity of the railway company should not affect the requirements of systems like: HR, payroll, financial and accounting, material management, car fleet management and so on. The reality was quite different. Historical circumstances, specifics of the company, autonomy, strong position of trade unions among many other things impacted management systems characteristics, so that they will not only meet not only the general requirements, but also numerous railway industry ones. The best example are the Engine Houses which had to take into account the hundreds of items constituting the train driver salary. More reasonable were the diversities of systems in the "front office" area that is systems related to the characteristics of the company. Back then Polish State Railways were the largest corporation in terms of employment, area of operation, ownership of property and the diversification of activities. Their activities were including not only the activities from the scope of the maintenance and repair of the railway infrastructure, manage the infrastructure and carrying out the movement of domestic and international passenger and freight trains of all classes and types but also support in the energy, telecommunications, information technology, facilities repairs, repair, health, security, design units, as well as conducting scientific research. The additional complications were technological restraints. By the end of the 1980s there were no country-wide computer networks but the company had working throughout the country and train movement processes covered the whole territory of Poland. Systems which were developed in these conditions used telephone or telex network. In some cases as a method of data transmission was used collecting entered data and transferring them to the Data Center on different available in a given

period media or just printing them and transferring to the destination in the printed form. With all these limitations multi-year operations of country-wide management information systems were a great success.

3. Selected management support systems implemented in the 1980s

Many management support systems had been developed until the end of the 1980s. Few of them are interesting because of particular importance for the company and the fact they were leading solutions in Europe in this area. Those systems were CETAR, BEWAG and INTERWAG in the front office area and GOSMAT in the back office area [1].

CETAR is the central system for calculating and settling debts for freight. Its concept was established in the 1970s and the main features include: computing dues, automatic billing of PKP clients, settling debts with foreign railway authorities, the making-out of physical statistics, financial statistics and analysis to illustrate the cargo freight. In a sense, it had become a victim of its quality, because the client was not interested in its modernization. Only the current adaptations to legislative changes and organizational changes in the PKP enterprise and in the company PKP Cargo were done. The System ceased to existence in 2007. With it the last machine of ODRA/ICL type which was supporting management systems was turned off.

BEWAG is the central records of wagons. Its goal was to operate records of railway wagons. For each wagon were recorded: operating and technical characteristics, financial and accounting information, repair data and archived data. The database established on the basis of wagon status defining cards everyday was updated by telegraph messages about shopping, deletions or by monthly reports about included and excluded wagons according with agreements with their owners. The results were submitted to the terminal screens, by telegram or in the form of prints documenting income, payments, depreciation and containing a statement of quantity-value wagons required for the approval of the balance sheet in area of PKP assets. Draft plans for wagon repairs were also generated.

INTERWAG. The aim of the system was to provide financial and statistical information about the exchange of wagons in international traffic. The information concerned the settlement rents and included comparative lists to check the correctness of the calculation of the rents and the data for the analysis of wagons circulations across the borders of the state. Input data were derived from lists established at border stations after train acceptance or transfer or passed by radiotelephone inventory reports. The system gathered over 10,000 messages a day. Users received billing statements daily, every ten days, monthly, quarterly and on annual basis. The statements were delivered to the Central Office of Foreign Accounts (CBRZ) and they included: wagon aid accounts, settlement accounts for foreign railways,

sealed PKP wagons turnover, accounts for the use of wide track wagons, reports of the time stay of wide track wagons in handling areas, exchange load reports from border stations, list of foreign wagons on PKP network, number, status and stay time of PKP wagons abroad, exchange of wagons reports according to border stations.

GOSMAT is the central material management system, which dates back to the 1960s, when it confined to the records of status and material flows. Since 1976, the system has been implemented on the entire rail network. The aim of the scheme is to provide users with the necessary accounting information and financial information of the material circulation characteristics in both product structures and organizational structures on the selected level of aggregation and management information needed for decision making. After multiple modernizations system is still operating and it supports a wide range of Group companies and other entities. GOSMAT currently uses Oracle Database and SAP Business Objects. A few years ago it was considered as one of the best material management systems with the title "Market leader in 2006, Euro Leader" awarded by the magazine *New Industry* (*Nowy Przemysł*) and it was highlighted at rail industry conferences.

4. Changes related to the transformation of the political system and access to new technologies

Since 1989, the political changes made new methods and technologies available because embargo on the modern information and communication technologies was lifted. In 1989, part of a World Bank loan granted to PKP was spent on IT projects. To enable the construction of modern enterprise management systems computer network is required. Packet network according to CCITT recommendation X.25 was selected to implement. In 1992 contract for the supply of equipment and the construction of the network KOLPAK was signed with the American corporation Sprint. KOLPAK was first countrywide packed network in Poland. It was used not only by the railway company, but it to other state institutions took advantage of it. The aim of the network was to enable the implementation of projects in the field of management called SKPZ (Operation and Management Information System of the Enterprise). SKPZ consisted of two main components **OMIS** (Operational Management Information System) and **FMIS** (Financial Management Information System) that with the KURS-90 system supporting activities in the field of passenger transport were supposed to be a new quality. OMIS and FMIS were integrated and centrally managed systems using state-of-the-art technology at that time. The goal of OMIS project was to create operation management system by PKP IT Department on our own. Applications of the system has been implemented and modernized since 1995. The aim of FMIS project was to purchase and adapt integrated financial management system which used the same

hardware and software platform like OMIS (operational system OpenVMS and Oracle Database). In the SKPZ project special attention was paid to ensure the operation and business continuity, hence the choice of hardware platform AXP Alpha systems in the OpenVMS cluster environment. Given that the KURS-90 system also worked with high reliable infrastructure Tandem and also X.25 network was characterized by high availability, in the 90s PKP has become a national leader in robust country-wide management information systems. Despite the technical reliability of the hardware and software platform created opportunities were not used due to the fact that the OMIS system design and adaptation to the PKP needs and the implementation of FMIS system lasted too long. System hardware platforms were no longer so important for software vendors (Oracle), and equipment was no longer sufficient for a large company. The OMIS project isolated applications related to the timetable (RJ) because performance of Alpha computers on 1994 proved to be insufficient for these applications. Thus, in 90's following key management systems replaced obsolete ones: KURS-90 in the ticketing and reservation, OMIS on the description of the railway rolling stock records, management and operation of commercial wagons freight, RJ in the creation and distribution of timetables, and FMIS in the range of company financial services [2].

All of the above-mentioned systems have used a X.25 network KOLPAK, and since 1999 the IP network implemented by IT Department of PKP with the DEC and Cisco routers and SDH 2 Mbps links. It was one of the first country-wide private IP network.

5. Selected systems implemented in PKP group companies

January 1, 2000 pursuant to the Act of 8 September 2000 on commercialization, restructuring and privatization of the state enterprise "Polish State Railways" [3] national railway company was converted into a joint stock company. In October 1, 2001 it was divided into a number of companies. This law was inspired by COUNCIL DIRECTIVE of 29 July 1991 on the development of the Community's railways (91/440/EEC) [4] requiring the separation of passenger and freight transport roles of the infrastructure management role. The following entities were created: PKP Polish Railway Lines - the infrastructure manager, PKP Cargo SA - the main freight carrier and logistics operator, PKP Intercity - qualified country-wide passenger carrier, PKP Przewozy Regionalne - a passenger carrier offered country-wide local, regional and inter-regional trains except qualified to operate a PKP Intercity company. Also brought to life a number of smaller entities: carriers operating passenger (WKD, SKM), and freight (LHS) which benefited from a dedicated infrastructure. In addition, several established companies with infrastructure: PKP Energetyka, Telekomunikacja Kolejowa and PKP Informatyka. PKP Informatyka took over the information technology services for the companies, but

without a monopoly position. Only two of the railway companies have implemented FMIS system: Telekomunikacja Kolejowa and PKP Informatyka. They used the previously conducted studies for FMIS system and in a short time made the implementation of Oracle Applications. The reason for the resignation from FMIS were not the technical or functional deficiencies that have been overcome. More important was the fear of assigned costs incurred in the implementation in the huge PKP enterprise to small companies. Company, which almost as quickly implemented **Oracle Applications** now known as **Oracle e-Business Suite** was the LHS. Oracle Applications were the first of ERP system implemented in the companies formed from the PKP. Another company that has implemented this system in 2007 is PKP Intercity. In subsequent years PKP Intercity has implemented data warehouse system Oracle Business Intelligence (BI) [5]. Oracle e-Business Suite in PKP Intercity has passed a serious test, when as a result of the reorganization of group companies PKP Intercity being exclusively engaged in the qualified passenger carriage took over from PKP Cargo locomotives to operate the passenger carriage, engine houses and repair facilities and from the PKP Przewozy Regionalne inter-regional passenger services. As a result of this reorganization, PKP Intercity increased several times in the area of the duties, assets and employment. The reorganization has not improved financial results of the company, but the system has passed this exam. Only the hardware infrastructure had to be upgraded because it was designed for a much smaller company. The proof that the system operated well for PKP Intercity, is running in 2012 project INTER12 - implementation of the new version of Oracle e-BS R12 and the new version of Oracle Business Intelligence systems.

The largest PKP Group companies have chosen SAP ERP system. The first implementation of SAP ERP in the companies of the group took place in PKP Regional Services. This was before it municipalization and leaving of the PKP group. Another implementation has been carried out in PKP Cargo, including a very difficult area for Polish railway HR. It has been really a big challenge, given the scale and complexity of the company payroll. The largest in the scope and scale, implementation was carried out in several stages at PKP Polish Railway Lines. Implementation has begun with the selected modules of approximately 300 users, and during next three years expanded the by implementing appropriate new modules and hardware components. Now the system supports more than 2,000 users. After the implementation of the first group of modules SAP ERP data warehouse SAP BW and SAP Business Objects reporting platform have been deployed. It is one of the largest SAP system implementations in Poland. In addition, the SAP ERP system has been implemented in the following companies: PKP SA (parent company of the group) and PKP Energetyka. Larger companies have decided to choose SAP system whereas smaller companies remained Oracle eBS system

and Oracle Business Intelligence. Oracle BI system is also being implemented in PKP Cargo.

Significant changes also occurred in the area of core activities management support. PKP PLK has introduced a SEPE system (Registration System of Operation). It maintains and displays the status of real time train traffic throughout the rail network managed by PKP PLK. It is developing SKRJ system (Timetable Constructing System), which will replace the RJ system. In 2007 implementation of the system SILK (Railways Information System) started. SILK is a typical GIS. SILK is carried out using Bentley and Oracle Spatial tools by PKP Informatyka with SHH - company specializing in GIS. Since 2008, the modules of: real estate, sections of railway lines with functionality of LRS (Line Reference System), internal railway maps and public railway maps has been implemented.

PKP Cargo has become the main beneficiary of the OMIS system whose applications support services freight and rolling stock. Applications of the OMIS system between 1995 and 2007 replaced earlier systems including BEWAG, INTERWAG and CETAR. Now the system consists of:
- Registration Application Group (ETP - traction registry, EWAG – wagons registry, GPW - private and rented wagons management)
- Freight Shipments Commercial Service Support System (OHPT - commercial freight shipments service, UMAK - acquisition agreements, ON - dues calculations, RZK - international settlements),
- Wagon Management and Freight Shipment Tracking Application Group (KPS – station operations guiding, ZPWO - foreign empty wagons returning, WIP - wagons and trains),
- Database of whole rail network description connected with POS application operated by PKP PLK.

Now PKP Cargo has started the implementation of Maintenance and Rolling Stock Management System based on IBM Maximo.

The second freight carrier PKP LHS has implemented INFO-LHS system – dedicated, integrated freight management system by PKP Informatyka.

For PKP Intercity basic sales system is KURS-90 which has been enriching from 2008 with capabilities of KURS-2008 system which is still being developed.

All freight and passengers carriers are users of the RJ or SKRJ systems, placing orders and running the trains in accordance with the timetable.

6. PKP group changes and challenges in area of management systems

Since 2012, a lot of changes occurred on the management of PKP Group companies. New managers put a lot of emphasis on intensifying joint operations of amongst group companies in order to reduce costs by exploiting economies of scale. Unification would bring many benefibeetween ERP systems. At the front

office area most companies have to operate their own system to suit the specific business requirements. On the other hand, the group will experience further changes. PKP PLK is leaving of PKP Group as the state infrastructure manager, PKP Cargo is partially privatized. Several other companies are awaiting privatization. Expecting significant changes companies invest only in the most urgent task.

All management systems require modernization and integration. Many systems in one organization existed side by side. Multiple interfaces were built between them but some of the needs are still unmet both quantitatively as well as qualitatively. There is a need for such integration of systems within both front office and back office areas work together as the client and the server. These are the known Web Services integration and data buses. Many systems include them or are adapted to cooperate with them (SAP, Oracle, IBM, KURS2008) but there is lack of appropriate standardization. The big tasks are the implementations of document management systems to implement business processes in such a way that they download data from and insert data to appropriate management systems. Most companies have already started work in this area.

In the front office area of PKP PLK the most important is development of rail network and real estate management system which could locate and list all investments with precise spatial location. Mmore accurate representation of the rail network is required (tracks instead of lines).

For freight carriers important issues are: cooperation with the clients and other carriers, the electronic exchange of information and the accurate information about the current location and the time of delivery of freight shipments. Implementation of the electronic consignment note system was completed in September 2013. The key issue now is to optimize the maintenance of rolling stock with IBM Maximo system.

In area of passenger services, the most important thing is to develop a common ticket sales platform where everyone could buy ticket regardless of the initial and destination stations, regardless of the number of direct trains and the number of carriers, at the lowest price, taking into account all available promotions and discounts, using any method of payment. PKP Informatyka declared to develop such platform.

At the end a few words about the technological challenges. Requirements, as to the availability and efficiency of processing have led to a situation that the systems are operating in many different sometimes quite exotic platforms. The development and dissemination of virtualization, high availability and performance maintenance techniques allows implementation of the management systems on the standard, uniform of hardware and software infrastructure. Using the features offered by consolidation, virtualization and automation it is possible to get huge cost savings. Consolidated and virtualized systems with automating maintenance tasks enable usage of cloud computing. The largest group companies can afford to im-

plement private cloud. It has many advantages but the operation of one cloud instead of multiple cloud solution will be much more economical. Smaller companies should use the services provider specialized in cloud computing services delivery. In author's opinion it is worth for the group that one company has been supplier of cloud computing services for all group companies and for other entities.

Some modern information systems, for example Oracle Database 12c are prepared to share the resources to the various players.

7. Summary

The article summarizes the history of information management systems in Polish railways. It is interesting what factors influenced that certain systems were replaced soon and some were exploited even for decades. Let us examine GOSMAT system, which has been changed technologically and architecturally and which has been used for more than 40 years. This is not an isolated situation, as systems of leading manufacturers (Oracle, SAP) also have a similar longevity. Let's look at the main features of this system.

Its purpose is to collect and share data on trading material for many independent business entities that use a single index of the material. It is implemented through a central database with quantity and value information. The basic features of the system include:
- Presentation of current and reliable data concerning the economy of materials at different management levels and the required level of aggregation;
- Quick and reliable access to information about current state of stocks in the company organizational units in the required form;
- Easy implementation of new reports at the request of the Customers;
- Provide user-defined reports within the Intranet or the Internet from anywhere in the world according with the requirements of security;
- The possibility of a complete audit of the users activities;
- Provide for the exchange of data with ERP systems;
- No need to install, configure and administer the workstation software;
- Any operating system and low requirements on the workstation.

The factors that determined the longevity and still high evaluation of system (awards and honors in recent years), according to the author are:
- A good definition of the requirements and correct implementation, taking into account the possibility of making functional and non-functional changes;
- Current and clear system documentation;
- Flexible parameterization of the system;
- The use of appropriate tools and platforms (Linux, Oracle Database, SAP Business Objects) and their appropriate use;

- Switching to new technologies (changing system platform, database, application, virtualization etc.);

- Quickly adapt the system to changing user needs;
- Maintaining a dedicated team responsible for the development and operation of the application.

Even compliance with these requirements does not guarantee continuity of operation. With the implementation of ERP platforms, customers deploy applications that are running as a part of the systems. According to the author, GOSMAT system can only survive as a part of the ERP system created by PKP Informatyka for the SMB sector companies. GOSMAT as a stand-alone system is likely to disappear from the offer within a few years.

The paper shows that while the management systems made lot of work, but because of the great organizational changes resulting from the Act [3] and subsequent reorganizations, changes of plans, changes of ownership, the separation of regional services to the local authorities current state of information management processes and the systems supporting them is not satisfactory in terms of functionality and technology. Even when systems provide excellent support in terms of availability and performance, they are not the best solution in economic terms. According to the author, information management systems are the subject that PKP Group companies should invest to enable faster decision making at lower cost through the use of new technologies and market opportunities.

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