

# European railway operators' experience in managing the dependability and safety of technical assets using advanced digital technologies

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**Abstract.** The Aim of the paper is to analyze and examine the experience of the railway companies of the European Union in designing technical asset management systems based on advanced digital technologies. Railway companies are interested in the development of efficient maintenance and repair strategies that allow increasing the volume of traffic with a high level of safety and reliability using the Big Data produced by diagnostic systems. **Methods.** A comparative analysis of the best practices by European railway companies was performed, the employed digital technologies were compared, and the best known and commercially available software solutions for constructing an asset management system were reviewed. **Findings/Conclusions.** Railway companies will have to make a lot of effort in order to not let the vast current expenditures associated with the digitization go to waste, since the deployment of new technology will meet the resistance of the existing system of management and allocation of responsibilities between levels of management within a company. The generic architecture of the European asset management information framework is a highly diverse range of IT solutions, which is a great challenge, as any modification to the operation of the software system requires significant time, managerial and financial resources. In this context, most successful are the companies that have invested in the development of own digital asset management frameworks.

**Keywords:** technical asset management, dependability, safety, risk, railway transportation, railway company infrastructure, maintenance, decision support, digital technology, software, URRAN.

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## 1. Introduction

This is especially vital in dynamically changing circumstances of the post-covid world and low oil prices when the established economic relations between countries are being replaced by others due to new societal demands in essential commodities, medicine and equipment and due to market conditions. Nowadays there appear new logistic supply chains and transport routes respectively that have not been used before. In this context we may expect a demand increase for transportation in one direction and a downright cut in other. Such a disproportion can bring a long line of serious problems for railway companies; in particular they have to invest much in renovation and improvement of their infrastructure, to maintain it in good state while supporting a growing volume of transportation. So, railway companies are interested in developing efficient maintenance strategies allowing to increase transportation volumes with a high level of safety and dependability while keeping risks at an acceptable level, based on so called Big Data of diagnostics systems. In order to efficiently manage railway infrastructure and rolling stock, one shall know their current technical state and be able to predict their state in future.

## 2. State-of-the-art of digitalization of infrastructure maintenance on EU railways

At present there are a lot of talks about the demand for implementation of disrupting (including digital) technologies on railways. Besides obvious benefits, digitalization can bring some serious problems for railway companies. There can be cases when a grade of automation has been wrongly chosen, or wrong parameters have been used for generation of a database of technical assets, or even worse, a company has no objective information about a current real state of technical assets, and available information is just some irrelevant reports produced by quasi-automated systems that are operated in line with the processes described by hired business consultants.

It is also very important to have a clear idea about the size of planned financial expenditures. Advanced technologies of data collection, transfer and analysis in the nearest future can radically change the maintenance rules adopted today on railways and in principle based on a normative approach. Monitoring systems for technical facilities of infrastructure and rolling stock are becoming more available, and they generate huge amounts of data that has been called Big Data, Internet of Things (IoT), Internet of Services (IoS), machine self-learning – all these concepts are actively taking their places in short-term digital strategies of railway development. Today the hot subject of researches is becoming the search for a balance between a rate, process costs, data transfer speed and power consumption of such multisensory systems. As a small example, there is DIANA system [1] developed by infraView for the purpose of diagnostics and analysis of DB infrastructure components. In 2016 over 6500

switches were connected to it, while in 2019 they already amounted to 25 thousands, and in 2020 the system controls 30 thousands of switches. Even today such smart systems begin to generate very huge amounts of data. Their transfer, storage, processing and analysis will become important issues in the years to come. Therefore, there arises a question whether these Big Data are consolidated, analyzed and used by railway companies in the right way. As when using prediction, it is difficult to assess whether various risk levels are acceptable and to take measures that would have seemed too risky before. For instance, one may reduce redundancy and cut the costs of technical maintenance if a decision making person believes it acceptable when a wheel pair achieves a limit state prior to a scheduled repair, though previously he would immediately have sent it for repair. However, while balancing at the level of risks, one should understand that decision makers will also have to balance at the level of responsibility for risk-related decisions made. Therefore, railway companies will have to take a lot of efforts so that the huge investments that they are currently putting into digitalization should not be lost, since the implementation will face opposition from the established system of administration and distribution of responsibility among management levels within a company.

In this context, some positive experience accumulated by the Federal railways of Austria ÖBB can be useful for other railway companies. ÖBB strives to take a lead in implementing ISO 55000 on railway transport and successfully verifies this intention in practice, by getting the ISO 55000 asset management certificate the first among all European railway companies in February 2019 for shifting to track maintenance based on the following principles:

- periodic full renovation of track;
- application of a current maintenance program combining preventive measures and those based on information about a real track state received by regular inspections;
- cancellation of permanent speed restrictions on mainlines;
- rehabilitation of roadbed when necessary on mainlines with dense traffic and at locations of switches.

The company experts have developed a unified network plan of asset management detailed for each technical department.

The ÖBB administration pays a lot of attention to the issues of IT support for the asset management system as a major tool for implementation of this methodology. Thus, from 2013 till 2018 the ÖBB management allocated over 12 mln Euro for the development of an IT platform. As a result of the work, Austrian engineers integrated 360 various databases into one database in order to construct an infrastructure asset management system.

Italian railways RFI became a second European railway company who was certified for their asset management system. This has been the first and the only certification in Italy accredited by Italcertifier through Accredia for physical assets management. The cost of the certification for RFI was over 40000 Euro. As the project manager

Donatella Fochesato said, during the certification procedure 104 processes and 387 sub-processes of the company were described.

The certification is part of a wider strategy aimed at further improvement of network management and generation of an added value for the company as well as for concerned parties.

Irish Rail has invested over 20 mln Euro in constructing an IT system of asset management.

Belgian railways, Infrabel have spent over 10 mln Euro for the development of an IT system for asset management.

General information about EAMS (Enterprise Asset Management System) systems used by some foreign railway companies is given in Table 1.

The generalized architecture of the European asset management IT platform is presented in Fig.1 (authored by Jude Carey, Irish Rail). One can see that it provides rather a diverse spectrum of IT solutions, which project managers in charge of introduction of an asset management in companies admit to be a big problem as making any changes to the platform's software is very time-consuming and requires a lot of financial resources and interactions with an IT department and a software supplier.

**Table 1. Examples of EAMS systems at foreign railway companies**

Company	Type of EAMS or auxiliary MMS	Year of operation start	Current estimation of satisfaction with applied SW
Irish Rail	Maintenance Management System (IT-tool): SAP PM	Since the beginning of 2000th	There are proposals to improve the functionality, however the high cost of SAP extension prevents the company from including this work in the maintenance contract. Plans are under discussion to transit to IBM Maximo by 2025, though it is complicated to abandon the elaborated solutions, and switching to other IT platform results in a lot of administrative and technical complications
Infrabel, Belgium	SAP	-	-
Network Rail, England	ELLIPSE (supplied by ABB)	2004	No replacement planned, alternatives often proposed, but it would be hard to change the system due to administrative complications, other systems have their own drawback as well
ADIF, Spain	ADIF – proprietary system for tracks and other infrastructure (not for stations)	-	Trying to improve and integrate it with other enterprise systems into a unified management platform
VAYLA, Finland	Raid-e systems (proprietary) RATKO – main data base for railway infrastructure RAIKU – tool for generation of reports about current maintenance (for MMS) RYHTI – tool for planning of infrastructure renovation and refurbishment RAHTI – tool for planning of physical assets	Started at 2016	Still under introduction, early to make conclusions
ÖBB, Austria	Proprietary systems. ARGUS – tool for resources planning MAZE – tool for inspection and harmonization of documents AUER – tool for maintenance invoicing	Since the beginning of 2000th	Systems under permanent improvement. Transit to SAP had been discussed, however it happened too expensive.

Generalized architecture of the European asset management IT platform

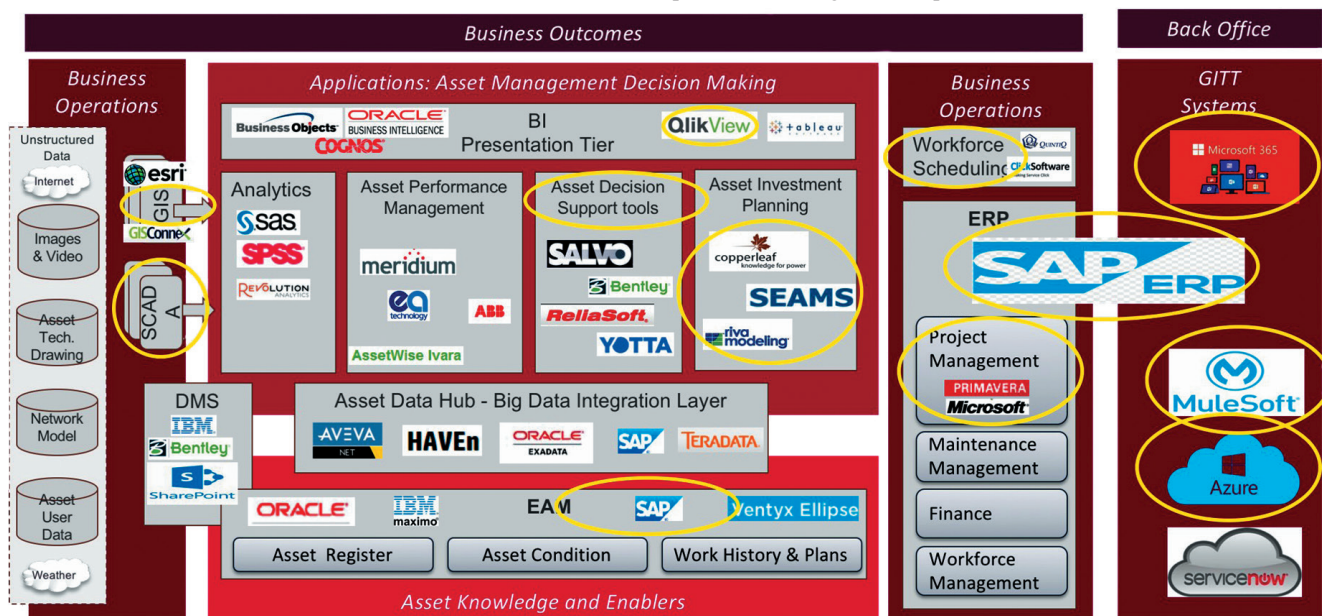


Fig. 1. (authored by Jude Carey, Irish Rail)

### 3. UIC projects, international interdisciplinary consulting companies' experience and best practices

Assuming the importance of the assessment of expenditures required for maintenance and renovation of a railway network, the International Union of Railways (UIC) as early as 1996 started to collect and analyze respective data within the project Lasting Infrastructure Cost Benchmarking (LISB) [2]. Infrastructure companies from 14 European countries have been participating in the project for over 20 years. The goal of the project is to define levels of railway companies' costs for maintenance and rehabilitation of the current infrastructure as well as to identify factors influencing these costs. It has been found that higher density of a railway network traffic in some cases has resulted in increase of costs for technical maintenance approximately by 5 per cent, and for renovation – by 16 per cent. The LISB project became a starting point for accumulation of statistical data about infrastructure maintenance, collection and analysis of best practices of railways, and exchange of experience among the participants.

In 2007 the UIC established a special Asset Management Working Group (AMWG) that combined the representatives of 10 European railway companies. Russian experts joined the group in 2016. The key areas of activities of the Group are:

- Research in asset management to promote the development of railways;
- Selection of an asset management strategy for railway enterprises;
- Identification of factors accompanying the optimization of asset management methods;
- Improvement of existing methods of asset management;

- Exchange of advanced experience in the area of asset management in the railway domain;

- Unification of methods and development of common approaches, guidelines and standards for railways to introduce technologies for efficient management and decision making support.

In 2010 the group developed the Guidelines for the Application of Asset Management in Railway Infrastructure Organizations [3], which has since been updated regularly based on the annual work results of the Group. In 2015 a Shortlist of Cost Drivers in Railway Asset Management was issued [4]. Based on the statistical data of the project participants, the document identified the impact of various cost factors (so called cost drivers) on the costs of infrastructure technical maintenance, repair and renovation. It was noted that there are quantitative and qualitative cost drivers. Qualitative cost drivers could not be characterized by quantitative values, so they were presented in the document in a descriptive way. In 2016 the UIC issued the ISO 55001 Guidelines for the Application of Asset Management in Railway. The Russian participation in particular contributed to this international document with the experience accumulated by Russian Railways during the development and application of the Integrated system of dependability, risks, resources at all lifecycle stages, called URRAN for short [5-7]. Special attention in the document was paid to risk management. Compared to any other such documents, this document allows to implement the key principles of asset management: “cost reduction by doing the right job at the right place at the right time, as well as by coordinated activities to achieve the best balance between maintenance, renovation and improvement of the entire asset database”.

In 2020 the Group initiated a new project called Asset Management Whole System Decision Making (WiSDoM). The goal of the project is the development of the concept and



respective methods and tools for the common asset management system of decision making (hereinafter “the System”) intended to ensure railway asset management. The System concept foresees the integration of the “system of systems” approach used in other industries with existing approaches to asset management and very similar in many aspects to the URRAN methodology. The roadmap of the project provides for the development of the concept of the System implementation for the entire infrastructure, common processes and criteria for decision making, definition of methods and tools ensuring decision making, onsite testing, validation of applied methods and proof of concept. The project is planned to last from January 2021 till December 2023.

Besides the Group’s permanent members, there are also representatives of interdisciplinary international consulting companies, research institutions and transport companies of Austria, US, Great Britain, Ireland, France, Netherlands etc who take part in the AMWG regular meetings. Since this market is rather young, let us dwell upon them in more detail.

Oxand [8] was founded in France in 2002 and is a leading consulting company in the area of construction of asset and project management systems. The company’s portfolio has over 1500 project references in management of realty, railway infrastructure, power supply and industrial enterprises. The key tool is a proprietary software tool Simeo™ that has in its database the information about over 600 types of assets, analysis of 70000 km of railway infrastructure and over 40 mln m<sup>2</sup> of realty. The system incorporates a decision making support module that uses statistical data about various types of technical assets accumulated for 15 years. The major indicators used for decision making are RAMS parameters.

Systra Solutions [9] is an international engineering and consulting group. It was established by French railways SNCF in France in 1957. It offers its own software solutions for constructing lifecycle models, planning investments, managing risks and safety, optimizing costs as well as constructing a predictive maintenance system based on Big Data.

Assetsman [10] was established in France in 2001 by Dr Celso de Azevedo, the pioneer of introduction of an asset management system in France. The company offers business consulting services, trainings and implementation of an asset management system for industrial enterprises using their own software modules such as AssetsValue, AssetsBudget and AssetsLifetime that cover all issues related to management and decision making support for technical asset management based on RAMS, LCC and risk analysis. For training and workshops the company uses the business game AssetsGame. The company is a member of French Institute of infrastructure asset management (inframi) and provides supporting services for ISO 55001 certification.

COSMOTECH [11], France, founded in 2010. A global supplier (vendor) of Enterprise Digital Twins software and applications for simulation and optimization of corporate operational efficiency. The company has developed a large library of customizable models and templates.

3B infra [12], Austria, founded in 2008, provides business consulting services and system solutions for asset management, including realty, technical maintenance of a customer’s infrastructure, costs planning and control using a proprietary integrated system of a railway company’s infrastructure and operations management – INFRA LIFE. A common software platform allows to take into account the current state of infrastructure, to record costs, to plan repairs and to support decision making based on predictive analytics. It can integrate any existing systems of a customer into its control loop.

ALD [13], Israel, established in 1984. The company is specialized in risk analysis, dependability, fail-safety and FRACAS systems (Failure Reporting Analysis and Corrective Action systems). The company offers the following software solutions:

- FavoWeb, Internet-based version of dynamical FRACAS system, calculation of RAMS parameters, lifecycle cost, analysis of a customer’s risks at the level of the whole enterprise. It is capable of integration with any existing databases of a customer;

- RAM Commander – 30 modules replacing a dependability engineer’s functionality and automating all his tasks – from prediction of parameters to fault tree analysis at all levels: components, units, systems;

- Safety Commander provides an integrated assessment of fail-safety at the level of a platform (aircraft, ship, train, etc.) by integrating fail-safety parameters at a higher level.

ReliaSoft [14], US, established in 1992. The company provides consulting and training services, licensing, supply of software. ReliaSoft software applications present a wide range of engineering simulation methods and dependability analysis at the stage of a technical item design.

SAP SE [15], Germany, founded in 1972. The company develops automated management systems for such internal corporate processes as accounting, trade, manufacturing, finances, human resources, warehouse management etc. Besides supply of software, the company offers services in its implementation using its own implementation methodology (the initial name was ASAP – Accelerated SAP – and now it is ValueSAP). SAP ERP is the most well-known software product for planning enterprise resources designed by the company. The implementation of the SAP ERP module includes the development and implementation of the following processes:

- Management of reference data;
- Overhauls and current maintenance;
- Annual planning of maintenance;
- Short-term planning;
- Execution of works and accounting of actual costs;
- Technical maintenance management.

ABB [16], Swiss-Swedish Corporation, founded in 1988, works in various industrial segments, however the key activities of the company are power supply engineering and automation technologies combined by a common digital platform ABB Ability™. The enterprise automation software enables the automation of manufacturing management, the

cut of energy consumption and the increase of production rates (operational costs reduction, lifetime extension, dependability and response improvement).

Maximo Asset Management [17] is a software solution by IBM (US) specifically tailored for management of all types of technical assets irrespective of their locations. IBM MAXIMO has 6 interrelated functional units enabling a full cycle of maintenance and management of corporate assets:

- asset management;
- supply management;
- contract management;
- stock management;
- project management;
- service management.

Maximo is a leading solution in the market of EAM systems and intended to increase the efficiency of an enterprise's asset management.

Of course, it is far from a full list of companies and IT products available at the market at present. It is worth noting that there is some general trend in the evolution of the market. The companies that started as developers of RAMS calculation software and only later proceeded to deal with the issues of lifecycle costs, risk assessment and related decision making support systems and methodology represent "the older generation" who have made an evolutionary way from just engineering to development of management tools and search for the most efficient strategy of technical maintenance and repair of infrastructure. The advantages of these representatives are a well-established engineering school and large libraries of technical failures of equipment accumulated for quite a long time. The companies who came into the market at a later stage grew as business consultants in the first place, providing consultations in construction and restructuring of enterprise asset management systems in line with the principles of the ISO 31000 series standards in risk management, the ISO 55000 standards in asset management, while providing services in certification, corporate training, development of business games. The software offered by these companies is rather focused on procedures for description of a customer's business processes, albeit with obligatory application of decision making support indicative markers using RAMS and risk assessment parameters. There is also a third group of companies who appeared around big infrastructure companies and, while providing services in elaboration of an efficient strategy of a customer's infrastructure maintenance, proceeded to maintain a customer's infrastructure by their own as outsourcing companies implementing their solutions in practice. Their advantages are own numerous and well-trained technical staff and availability of a multilayer comprehensive system of a whole enterprise management system using integrated solutions of SCADA systems and integration of a production and operations control loop with accounting systems, that enabling to practically implement principles of cost management and to calculate a lifecycle cost of equipment.

## 4. Conclusion

The paper analyzed the experience of EU railway companies in construction of a technical asset management systems based on advanced digital technologies. It is found out that a generalized architecture of the European information platform of asset management presents rather a diverse spectrum of IT solutions, which is a big problem, as making any changes to the platform's software is very time-consuming and requires a lot of financial resources. In this context the most successful are the companies who have invested in development of their own digital platform of asset management. To validate this conclusion, best practices of European railway companies were benchmarked, digital technologies used by railway companies were compared, and the most well-known software solutions available in the market for construction of an asset management system were reviewed. A conclusion was made that railway companies will have to take a lot of efforts so that the huge investments that they are currently putting into digitalization should not be lost, since the implementation will face opposition from the established system of administration and distribution of responsibility among management levels within a company.

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## The author's contribution

The author examined and analyzed the state of the art of development of a technical asset management system for railway companies of the European Union based on advanced digital technologies. It is found out that the European asset management information framework encompasses a lot of various IT solutions and in this case any modification to the operation of the software system requires a lot of expenditures. The author benchmarked the best practices of European railway companies and made a comparative analysis of digital technologies applied in asset management. It is concluded that the difficulties related to the introduction of advanced digital technologies are due to the resistance of the existing system of management and allocation of responsibilities between levels of management within a company.

## Conflict of interests

The author declares the absence of a conflict of interests.