Information systems for railway infrastructure management

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Abstract

As the railway market becomes more disaggregated and complex, comprehensive and reliable information systems are necessary to enable the integration of information flows, driving modernisation in the railway sector.

As a direct consequence of the implementation of EC Directive 91/440 splitting railway infrastructure from train operation, it has become necessary to know more about the core activities of the network provider, hence the development and implementation of information systems tailored to the specificities of the sector. Railway Infrastructure Managers need to be able to manage their level of activity against costs, while regulatory bodies, control bodies and researchers also require having such detailed information available, which is currently scarce and making a detailed analysis difficult.

Such hurdles were felt along the development of the EC 5th FP Research Project IMPROVERAIL (www.tis.pt/proj/improverail/improverail.htm) – IMPROVEd tools for RAILway capacity and access management, looking at some of the key issues towards the development of the railway infrastructure sector. Such need is stated in Directive 2001/14, by which Infrastructure Managers are obliged to set up fair pricing schemes based on effective costing mechanisms, regarding the provision of services to Train Operating Companies. To this end, information systems should be swiftly implemented, enabling timely and accurate management information support, on which modernisation of railways can depend. Top areas for integration include financial and economic issues (Charging), technical aspects (M&R), asset management and commercial information (market transparency). Such systems are expected to boost competitiveness of the sector along with optimised operational and management processes.
1 Introduction

Before the separation of train operation and track provision, in result of the implementation of the EU Directive 91/440, railways had little reason to concern about achieving a deeper understanding of their internal processes and cost relationships. Cost analysis of operation and infrastructure provision has since remained within the academic field. Today, railway infrastructure management is an emerging business sector on its own, needing to optimise its activity; in particular on the issue of crucial information for management, bringing this sector to the standards of other industries. To this respect, cost and performance related information is today required in support of a new setting for fair competition between railway and other transport modes. This ambition relies on the clarification of costs incurred by this sector, fair charging principles regarding trains operated under private rationale being required.

The context described is therefore characterised by a server/client contractual relationship established between IM’s and the Railway Undertakers. Indeed, in the wake of EC Directive 2001/14, Infrastructure Managers are expected to adopt more disaggregated cost analysis, relating the provision of services with actual costs. Rather than making reflect on these the inherited inefficiencies associated to “average costs”, charging should be based on the effective knowledge of costs incurred by the Infrastructure Management when opening up for a given capacity slot. Not surprisingly, the interest for complex information systems increases. Likewise other industries where integrated information systems have been emerging, railways seem bound to follow this path. Achieving success on that will further allow keeping track of a large number of indicators to support the core business activities carried out by Infrastructure Managers. To this respect, the key areas that have been individually analysed in the EC Research Project IMPROVERAIL were Fair charging for infrastructure usage, railway investment, maintenance & renewal decision-making and benchmarking for best practices. As seen in IMPROVERAIL, there are some forerunners among the Infrastructure Managers, which are already running integrated information systems such as PRORAIL, DB Netz, SBB, OBB, REFER. An example of these systems is SAP R/3 for internal data management, which have the potential to build a common platform for effective data exchanges among EU Infrastructure Managers. The design challenges are however considerable, as demonstrated for example by the very different definitions of cost categories that have been used in the past making it rather difficult to reach a common protocol for a system that would fit most IMs. To the extent that there are already several systems implemented, such as asset management systems (AMS) and Geographical Information System (GIS), these should also be taken into account in integrated systems. Cross-linking all this information effectively into an optimised Railway management and decision support tool has a large potential. The findings of IMPROVERAIL regarding track maintenance & renewal decision-making, infrastructure charging and performance benchmarking are addressed in this paper.
2 Information systems in support of M&R planning [2][5] [7]

For an infrastructure manager it is of high importance to have a clear view on the state of its infrastructure. In order to manage the maintenance and renewal process efficiently and economically, an infrastructure manager has to set up specific databases describing the infrastructure and its current state. These databases must provide up-to-date information on the infrastructure in such a structured way that the infrastructure manager can efficiently make use of it to develop its maintenance and renewal policy. To link these databases with others, e.g. cost related databases, has the potential to create powerful synergies for management and decision support systems. According to the UIC, the minimum required set of infrastructure data is as follows:

System database: General physical characteristics of infrastructure components, for example:

- Curves, connections, cant gradients, transitions
- Structures and earthwork, barriers
- Tunnels
- Singular points (building and various installations, etc)
- Service and emergency access points
- Drainage systems
- Position of overhead lines
- Switch and crossing locations
- Position of signalling installations

To be able to plan maintenance activities for the long-term, the information in this database about each infrastructure component should at least include:

- Identification number
- Location (number)
- Building year
- Deterioration models
- Expected lifetime

The identification number should be a unique key ID for database storage. The geographical location (as a number) should be included in the unique identification number of the component. This location number will be the key to integrate different databases further, for example with the use of a GIS interface. With regard to long-term planning of M&R, it will suffice to know when the infrastructure components have been built and placed (building year, production year) and what the expected lifetime of the infrastructure component is, according to experiences (deterioration models) and expected use.

Monitoring database: For long-term planning, a monitoring database is important to check the expected remaining lifetime of the infrastructure components. The
system should produce warnings to the infrastructure manager when a certain infrastructure component should be repaired or replaced. Such a monitoring database should contain up-to-date information on at least the following subjects:

- Recordings relating to track geometry and ultrasonic inspection
- Maintenance records for switches and crossings
- Evaluation files of the condition of components (sleepers, rails, fastenings, etc.)

“Action taken” database: The “action taken” database provides information enabling the infrastructure manager to obtain a realistic view on the remaining lifetime of a component. From the information in this database it should be possible to predict how many functional years the component has left, as a result of the M&R actions performed. This database should contain information on the following M&R actions:

- Work done on the geometry of the track and switches (levelling, tamping, aligning, local repairs, lifting, etc.)
- Work carried out on track components (grinding, replacements of sleepers, replacements of rails and switch components, welding of rails, work done on damaged rails, etc.)
- Infrastructure renewals

Incident and accident database: should contain an exhaustive inventory of incidents, accidents and disturbances as well as their causes and, if possible, their remedies.

Resources and costs database: contains information on all possible resources. The database stores information about staff (or contractors when the M&R work is contracted out), the equipment, track components, tools, rail and vehicle fleet, and cost management. The latter is often stored within an Enterprise Resource Planning, for example SAP. In the long-term perspective, the main concern to Infrastructure Management is the replacement of a component and its planning. With respect to the planning process for M&R on the medium and short term, more information is needed. For this purpose it is necessary to establish database links in such a way that information concerning inspection reports, current state information (monitoring database), maintenance history (incidents and accidents database, action taken database), quality indicators, etc. can be combined and analysed. This information, combined with the resources and costs database, represents a structured and efficient information support system that is required for a realistic medium and short term M&R planning. However, it should be mentioned that the data collection, maintenance and updating of such a comprehensive database is an extremely demanding and time-consuming task for the infrastructure manager. Another aspect that causes problems is the connection of the different existing databases, which are often set up by different people at different times, making its integration a difficult task.
Databases of fixed Assets (DfA): At SBB[2] the Database of fixed Assets is an asset management system that records and manages all data on its fixed assets and it represents the core information database of the infrastructure manager. To fulfil the various maintenance management requirements, the complex construction work, and optimisation of the track business, it is essential that all information on network condition, individual assets and their relationships are available at all times through the DfA. The DfA supports the SBB infrastructure manager in the demanding task of documentation and management. This solution centrally records all data relating to the rail infrastructure and makes it available at all times to the SBB managers, services, project leaders and staff. All information and data are also available to third parties for projects and planning parties. The DfA delivers a comprehensive range of possibilities for recording, managing and analysing the rail infrastructure data. The user access is provided by the use of many of the technical solutions and platforms available today, including Internet, Intranet, mobile computing and GSM mobile communication. For instance an employee of the IM may demand information on a specific object through his mobile phone and receives the answer on the phone display in the form of a text message. The solution adopted by SBB may be seen as example of good practice about the way ahead for efficient maintenance and management of a railway network. The DfA includes a rather exhaustive table, storing all maintenance or renewal actions that have been undertaken in the past.

Specificities of network data management in case of outsourcing of M&R activities should also be considered. In such situations, major long term decisions on M&R should be taken by Infrastructure managers themselves. The question of data management when outsourcing certain important activities should be raised. This should be assured either by the infrastructure management company or else in close cooperation with track contractors. If an infrastructure manager decides to outsource the maintenance and renewal work, the task of the infrastructure manager concerning the collection of infrastructure data will differ. Apart from some visual spot checks of the track, the IM is not itself collecting the infrastructure data. It has to rely on the data collected and presented by the contractors. The role of the IM turns into one of managing the data collection, instead of performing it itself. Therefore in the case that M&R is outsourced, the design of the information system should take the following concerns into account:

- Who is obtaining the data?
- By which methods?
- Who is storing the data?
- Is the data stored centrally or not?
- Who is analysing the data?
- What is the quality of the data?
- Who is checking the quality of the data?
- How often will the information be updated?
- How often should it be updated?
• Are there conflicts of interest with the contractors concerning the availability (and the storage location) of infrastructure data?

3 Information requirements for efficient railway infrastructure charging [3][4] [8]

The separation between train operation and infrastructure management made necessary a new business concept. It further raises the need for feedback relations among railway stakeholders enhancing efficiency on the railway transport. This implies implementing a market structure based on financial flows that should account for:

• Cost structures. Both internal and external costs should be reflected in the market. Cost efficient production should be a concern throughout the entire “production line”.
• Differences in companies’ cost structures. Relative differences in productivity among competing firms should lead to a situation where the most competitive firm wins contracts and is given opportunities to expand and evolve its production.
• Intermodal competition. The railway market should face the same external conditions as competing modes of transport
• No discrimination of operators, freight-companies and passengers
• Need for clear information flows between operators and infrastructure managers to secure that decisions are rational

Hence, infrastructure fair charging emerges as a crucial “part of the picture” required to fulfil the expectations that remain in railway transport

According to the EC Directive 2001/14/EC, charges must be paid to the infrastructure managers and be used to finance their business. In principle, the charge for the use of railway infrastructure should equal the cost directly incurred as a result of operation of the trains. However it may include a sum reflecting the scarcity of capacity. Moreover, the infrastructure charge may be modified to take account of the cost of the environmental impact of operation of the trains. The underlying assumption is that charging procedures are crucial to establish the right incentives for total railway production, competition between operators and among other transport modes. Provided that the other modes are subject to similar principles.

But to be able to apply charging methodologies based on the knowledge of such variables, Infrastructure Managers must have information at their disposal, which can only be obtained by means of suitable information systems. Some may be standard accounting systems, others simulation systems often based on studies carried out internally or by consultants. In any case, the data requirements supporting fair charging would have to cover the following elements:
• Wear and tear – Induced costs for maintenance caused by a specific train using the infrastructure
• Marginal costs related to signalling, surveillance etc – Extra costs of railway system administration should be included if these are truly marginal costs.
• Accident costs – One more train on a track increases the accident risk for passengers, employees and third parties.
• Environmental costs – Emissions and noise pollution are the main elements in this cost category
• Congestion costs – Each train added to a given network will rise, to an increasing extent, the expected delays in the railway system. This is an externality imposed by the operator on the others and should be internalised through a correct internalisation scheme.

To implement Marginal Cost principles combined with financial mark ups, as prescribed in the EC Directive 2001/14/EC would fulfil most of these requirements. But it requires that cost elements and drivers are identified and calculated at a suitable level of accuracy. This has been one of the major drawbacks for the application of such principles, as there will always be a great number of variables that affect these costs, and there will always be some inaccuracy and uncertainty in the calculations. It is therefore necessary to bring some level of uniformity to this process, including the criteria for allocation of overhead costs. Also different definitions of cost categories used in practice make it difficult to achieve data harmonisation.

Efforts spent on the harmonisation and the calculation can only be justified if associated costs are outweighed by the benefits accrued, which ratio can be significantly improved with the support of Information Systems.


Previous benchmarking studies (UIC - INFRACOST I-III) suggest that there are at least twelve European railways already that have committed themselves to exchanging limited cost data and information about their practices in order to improve their cost performance. However, it should be considered that even those who have not been involved in benchmarking before would certainly be able to start doing so, if data collection were not as time-consuming as it is now. To change this would almost certainly imply that Infrastructure managers (IM) would also be ready to benchmark for best practices in other fields such as quality and safety management systems, where great benefits might be gained from this sort of information exchange. Another issue are the asset registers, which currently are inadequate for successful benchmarking. Due to the complex nature and vast scale of IM, exogenous influences on performance, beyond the control of the IM, can mask the degree to which high or low performance is due to best practices or processes. The research undertaken in IMPROVERAIL identified the main barriers to effective and mutually profitable benchmarking, namely:
• The lack of incentive amongst some IMs to improve performance unless they are given strong encouragement in this direction by the authorities to whom they report.

• Inadequate data collection procedures for a variety of functional areas. IMPROVERAIL has identified weaknesses amongst the majority of IMs in all three areas in which pilot studies took place, the monitoring and control of delays and failures, safety management systems (where only a minority of IMs measure precursors or distinguish between major and minor casualties) and procurement (where most have no programmes for moving to a restricted number of approved suppliers as the automotive industry have done, and therefore little or no systematic performance data).

• Inadequate information systems, especially asset management systems

The lack of change of culture and lack of incentive to perform benchmarking are crucial issues in this respect, calling for sustained efforts and co-operation between IMs to agree on a common set of meaningful Key Performance Indicators (KPIs). In particular, the encouragement of full steerage from the stakeholders (the IMs) seems essential for application of practical benchmarking. IMPROVERAIL further identified the need to develop data collection mechanisms, supported by information systems brought up to the standards of railways/infrastructure managers such as SBB (CH), RENFE(ES) or PRORAIL (NL). The wider implementation of such system would therefore contribute strongly to regular benchmarking exercises, to the benefit of EU Railways. Moreover, the role of Information Systems in improving IM performance will depend on the development of specific modules built on integrated information systems, in such a way that a common set of KPIs can be fed from general data requirements.

5 Conclusions

Before the separation of train and track, the national railways were used to carry out an integrated analysis of costs and revenues considering both operation and infrastructure with little concern for a deeper understanding of the cost relationships, which have thus remained within the academic field. Upon the full implementation of the EU-Directive 91/440, the understanding of actual costs incurred by each side became crucial. In fact, to apply marginal cost-based charging it is absolutely necessary to have information systems available. Deeper and more detailed analysis requires comprehensive cost accounting systems enabling more powerful “drilldowns” into the databases in order to get e.g. useful correlation analysis, further providing additional features such as the calculation of Key Performance Indicators supporting the application of best practices.

Currently, some of those systems are standard accounting systems, others are simulation systems and some are based on more or less regular studies carried out by accountants and consultants. But as the railway market becomes more
disaggregated and complex, the demand for complex information increases. Regulatory bodies, control bodies and researchers need to have available detailed information. Accordingly, and due to the recent Directive 2001/14, IMs should consider developing and adopting a more disaggregated cost analysis. This is an important step for the management of the interactions with Railway Undertakings, allowing the provision of services to be related to actual costs. Integrated information systems should allow keeping track of costs and the identification of relevant categories, and its allocation to the access to the network. This applies also to the allocation of overhead costs that currently follows different principles, which is an obstacle to the accurate knowledge of costs drivers. It is therefore necessary to reduce those drivers to the minimum possible aggregation level in order to keep tight control over the costs which are driven by level of activity. By doing this it becomes easier to fairly reflect those variations in the applied pricing principle, in particular regarding SRMC. Currently, most IMs are either using integrated information systems or in the process of implementing them. Among these, SAP R/3 (and follow-ups) for internal data management could serve as a common platform for effective data exchanges. However, one further challenge comes from the very different definitions of cost categories used in practice that make it difficult to attain data harmonisation. Also asset management systems (AMS) combined with Geographical Information Systems (GIS) should not be overlooked when it comes to railway information systems. Such types of database provide accurate information about the exact geographical location of the infrastructure object. Linking this information to other databases would translate into a very useful management and decision support system for an IM. It is essential however that all information on network condition, individual assets and their relationships is updated continuously and available at all times.

The emergence of well integrated and complex information systems will depend on a strong commitment from the Infrastructure Managers at EU level. Based on the observed initiatives already underway in this respect, we expect a significant grow in the deployment of comprehensive and integrated railway information systems within the next years.

References

Systems’ – Institute of Transport Economics - Norwegian Centre for Transport