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Enabling Railway AM Optimization Using a Rationale KPIs Framework

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Abstract

Often the top management, in the phase of asset controls, finds itself overwhelmed by the availability of a huge amount of Key Performance Indicators (KPIs). Most managers are struggling to understand and identify the vital few management metrics and instead collect and report a vast amount of everything that is easy to measure. As a consequence they end up drowning in data while thirsting for information. This condition does not allow a good management of the systems. The research aim's is to help the Asset Management System (AMS) of a railway infrastructure manager using Business Intelligence (BI) to have a KPIs management system in line with the principles of AM presented by the normative ISO 55000 - 55001 - 55002 and UIC (International Union of Railways) guideline, for the specific case of a railway infrastructure. This work starts from the study of these regulations, continues with the exploration, definition and use of KPIs. Subsequently KPIs of a generic infrastructure are identified and analyzed , especially for the specific case of a railway infrastructure manager. These KPIs are fitted in the internal elements of the AM frameworks (ISO-UIC) for systematization. Moreover an analysis of the KPIs now used in the company is made, compared with the KPIs that an infrastructure manager should have. Starting from here a Gap Analysis is made for the optimization of AMS.

Keywords
KPI, Business Intelligence, Asset Management, Framework, UIC, Railway Infrastructure Manager.

1. Introduction

Performance evaluation is a fundamental principle of Asset Management. As a consequence KPIs are used by managers to understand if the activities they manage are being successfully conducted to maintain and improve the performance [1].
Therefore, is vitally important to understand and identify a few meaningful indices that, when properly measured, are capable to understand the trend of the managed activities.
KPIs can measure the company's performance in its most varied aspects and they should be defined as [2]:

- critical
- synthetic
- significant
- priority

Critical because the management makes its own choices based on them, *synthetic* because they are expressed by a simple or compound variable, *significant* as they well represent the business phenomena to which they refer and

priority due to their indispensable nature in the planning and control and risk assessment cycles at all company levels (strategic, managerial, operational).

In general KPIs can be grouped in order to provide an immediate overview of the progress of the business. The subdivision proposed in this paper is as follows:

- financial perspective;
- customer perspective;
- marketing and sales perspective;
- operational processes and supply chain perspective;
- employee perspective;
- corporate social responsibility perspective.

This work proposes a railway AM optimization using the framework presented by UIC Guideline[5]
The paper consists in 4 sections. In section I, after the introduction, is presented the AM standard, in section II is presented the literature review on KPI, section III describes the BI method adopted for the optimization of AM railway system, section IV-V contains results, possible improvements for future works and conclusions.

1.1 International Standard

In 2014, the British standard (BS) of PAS 55 were translated into international legislation by the ISO:
ISO 55000 - Overview, principles and terminology- which aims to provide a general vision on asset management and establishes its specific terminology and basic principles[1];
ISO 55001 - Requirements- defines which are the requirements of an efficient asset management system [3][3];
ISO 55002 - Guidelines for the Application- is a useful guide for the application of ISO 55001.

The international standard express the fundamental requirements of Asset Management:

1. context of the organization;
2. leadership;
3. planning;
4. resources;
5. operation;
6. performance evaluation;
7. continuous improvement.

The principle of performance evaluation makes the use of KPIs to fulfill its purpose. Transforming data into information is the key to measuring asset performance. The monitoring, analysis and evaluation of this information should be an ongoing process.
ISO 55000 states that the performance of asset management should be evaluated with respect to the achievement of the Asset Management objectives. It is also advisable to examine any opportunities arising from exceeding these objectives, as well as any failure to achieve them [1]**Error! Reference source not found.**. ISO 55001, regarding the performance evaluation [3] and ISO 55002 express what one should consider for the monitoring [4]. Below (Figure 1) AM framework is presented.

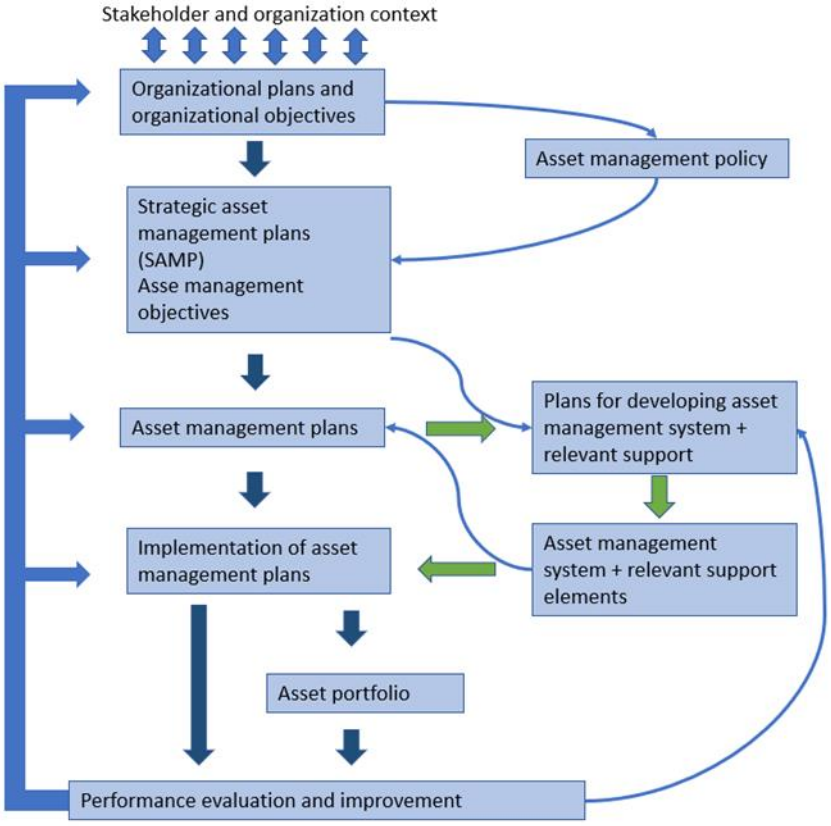

Figure 1. AM Framework ISO 5500X

1.2 The UIC Guidelines

In 2016, the Guidelines for the Application of Asset Management in Railway Infrastructure Organizations (UIC guideline)[6] was updated. It contains the guidelines for the application of the principles of Asset Management, imposed by the international legislations, to the railway sector. The application of these principles to the infrastructure must allow to maximize the profit for main stakeholders and users, in a sustainable way and under the most economically advantageous operating conditions.
This guidelines underline the importance to provide a measure of the effectiveness of implementation of each component of the resource management system, for example, the execution of work against plans and budgets; measurements of the impact of the Asset Management System implementation on infrastructure performance, e.g. conditions, failures, capacity, service impact, costs, etc.
Top management must control the wealth of the management system in a systematic and regular manner like:

- identify the gaps in the implementation of the Asset Management System;
- identify the root causes of deviations in performance measurements from target values;
- confirm that the implementation of the resource management system is driving sustainable performance, costs and risk levels;
- identify the actions for the short-term improvement of the infrastructure performance, where required, and the long-term continuous improvement of the components of the Asset Management System, including any changes to the general framework.

UIC guideline aim is to ensure that appropriate processes, requirements and technology are in place, to allow the monitoring and measurement of the Asset Management Plans, the implementation of the Asset Management System, the achievement of the Asset Management objectives. In **Error! Reference source not found.** UIC framework is presented.

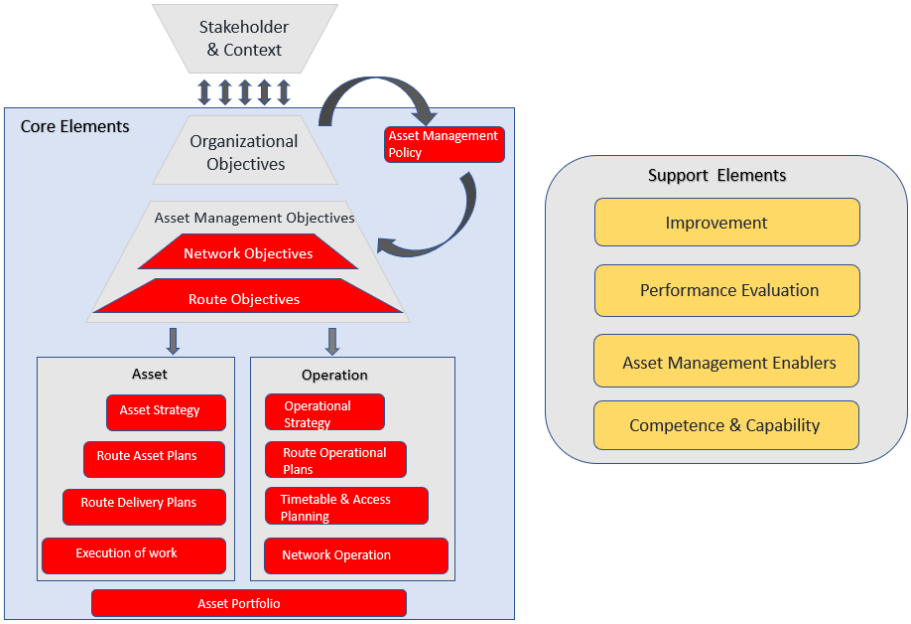

Figure 2. AM Framework ISO 5500X

2. Objectives

The aim of this work is to improve, using BI, the ability to evaluate the performance of the assets, to ensure the optimization of management and provide the guarantee that the organization (manager) is monitoring the aspects that can compromise the business objectives, through a systemic vision of the management system KPIs that allows an integrated reading of the performance results.
A well-structured evaluation system should include metrics and indicators that are associated with objectives and that are above all aligned with the objectives of Asset Management and corporate strategy.
The company should monitor the performance of the asset management system itself, in order to evaluate the effectiveness of its management system.
The gap analysis between Asset Management KPIs and those currently used will allow:

- to define implementations in terms of new KPI to be introduced;
- to verify the correct use of the KPIs in terms of improving the monitoring and improvement processes on the entire asset management system.

3. Literature Review

This section deals with the overview of literature related to KPIs. Major facility performance measurement practices include benchmarking, a balanced scorecard approach, post occupancy evaluation, and measurement through metrics of key performance indicators (KPIs). Douglas [7] asserts that benchmarking is vital in building performance measurement. Some of the articles referenced in this paper discuss evaluating the performance of an organization and its services. Preiser [8] said that organizational performance is closely related to a facility's performance. Cable and Davis [9] affirm that measuring performance by establishing key performance indicators helps the Top Management to make important strategic decisions. Baldwin [10] underline that performance metrics indicate long-term and short-term financial and performance goals, and are for a healthier relationship between customer and service provider.
Lebas [11] claims the measurement of performance expands the possibilities of examining the past and present and inferring future strategies for the proper functioning of the organization and for the achievement of its strategic objectives. Alexander [13] explains that facility management has a major impact on organizations, and its significance is increasingly being recognized.

Amaratunga et al. [14] argue that performance measurement is vital to the organization because it provides much-needed direction for decision-making.
Cable and Davis [9]explain that KPI's are useful for warn the presence of inefficiencies and unavailability. According to Amartunga and Baldry [15], the Procurement Executives' Association, described "performance management" as, 'the use of Performance Measurement (PM) information to effect positive change in organizational culture, systems and processes, by helping to set agreed-upon performance goals, allocating and prioritizing resources, informing managers to either confirm or change current policy or program directions to meet those goals, and sharing results of performance in pursuing those goals'. Neely et al. said that a PM system can be described as the set of metrics used to quantify both the efficiency and effectiveness of actions [16].
Neely et al. [17] claim that performance measure can be defined as one used to quantify the efficiency and/or effectiveness of an action.
Porter and Lawler [18] described a model where performance consists in 'efforts, ability and role perception'. Salmein affirms that the basic idea of performance is function of ability, efforts, and opportunity [19]. As Neely et al. [15] PM can be well-defined as the process of quantifying the efficiency and effectiveness of action. Thus, performance is the ability of an organization to implement a chosen strategy.
Developing performance metrics is an important step in the process of performance evaluation as it includes relevant indicators that express the performance of the facility in a holistic manner. Consequently, it is tremendous important to identify a set of KPIs to establish effective performance evaluation metrics. Performance Measurement (PM) and its framework areas are continually changing and developing.

4. Methods

The first task of this phase was the identification of the generic KPIs, starting from what the ISO 5500X regulation provides. In the Table 1 below are expressed KPIs identified.

Table 1. KPI's for a generic infrastructure

KPI			
Net profit	Total Return to Shareholders (TSR)	Debt / equity ratio (D/E)	Level of online customer engagement
Net profit margin	Economic added value (EVA)	Cash conversion cycle (CCC)	Online voice sharing (OSOV)
Profit margin	Return on investment (ROI)	Working capital index	Footprint on social networks
Operating profit margin	Return on investment (ROCE)	Operating cost index (OER)	Klout score
EBITDA	Return on assets (ROA)	CAPEX in relation to sales	Six Sigma Level
Revenue growth rate	Return on capital(ROE)	Price / Earnings Ratio (P / E Ratio)	Capacity Utilization Rate (CUR)
Promoter Net Score (NPS)	Customer satisfaction index	Customer Lifetime Value (CLV)	Process waste level
Customer loyalty rate	Customer profitability score	Customer turnover rate	Order fulfillment cycle time (OFCT)

Customer involvement	Relative market share	Conversion rate	Full, on time delivery rate (DIFOT)
Customer complaints	Brand equity	Positioning in search engines (by keyword) and click-through rate	Inventory Shrinkage Rate (ISR)
Market growth rate	Cost per lead	Page views and bounce rate	Change in project planning (PSV)
First Contact Resolution (FCR)	360-degree feedback score	Average duration of employees	Change in project cost (PCV)
Added value of human capital (HCVA)	Wage Competitiveness Index (SCR)	Bradford absenteeism factor	Earned value metric (EV)
Turnover per employee (RPE)	Return on investment in training	Waste reduction rate	Strength of the innovation pipeline (IPS)
Employee satisfaction index	Ecological footprint	Waste recycling rate	Return on investment in innovation (ROI)
Employee engagement level	Water footprint	Quality index	Market time
Staff defense score	Energy consumption	Overall Equipment Effectiveness (OEE)	First pass performance (FPY)
Employee churn rate	Levels of savings through conservation and improvement efforts	Product recycling rate	Rework level
Machine or process downtime level			

As a second step, the AM framework for a railway infrastructure was analyzed (**Error! Reference source not found.**), going to explain all its contents. Then the company was asked to collect in a database all their KPIs currently used. The database had to specify the following items:

Table 2. KPIs items

Process
Sub-process
Activity
Perspective examined
Importance-Definition of the index

How to measure (formula, percentage...)
Data collection
Target
Frequency of verification

The authors believe that in Table 2 there are the necessary information to make known the usefulness of each indicator, and its use. Until today, from corporates point of view, the organization is structured by business functions. This work want to change the point of view, restructuring the system according to the processes. To do this the actions start from the AM framework's components. Each KPI has been associated with the core element monitored (red elements in the **Error! Reference source not found.** of the framework).
A critical analysis of the indicators was then conducted on the basis of this database, aimed at verifying how they support the management phases, to:

- keep the objectives under control;
- make business decisions;
- keep risks under control.

These macro views are ensured in the framework by the components that collect the objectives of the Infrastructure Manager, useful to the Top Management, while the decision-making aspects are used in the strategic processes where the choices of intervention are made, planning them at the strategic level, used by the managers responsible for management, and, finally, in the risk control levels are made the operational processes of execution of activities, used by management (resource manager).
Then the different KPIs can be aggregated into a pyramid view as shown in Figure 3.

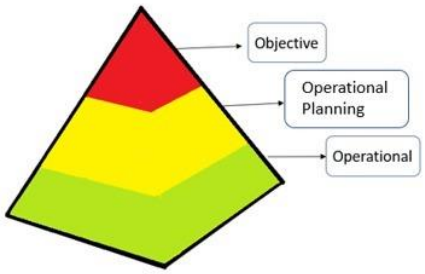

Figure 3. Pyramid macro-area view

Each area is characterized by external (stakeholders) and internal (structures employees) references with their own risks to be kept under control. Business objectives are the results that Top management intends to achieve over a period of time. The objective must be:

- clear and specific so as not to run the risk of thwarting efforts to achieve it;
- measurable through pre-established quantitative parameters.

Once the 'Objective' have been outlined, the management proceeds with the 'Operational Planning', planning the actions to achieve them; considering the resources available, it draws up a strategic plan to achieve the objectives. This can be done through the use of different tools.

5. Results and discussion

For a company operating in the field of Concessions of Public Assets (as in the case of RFI) one of the main objectives must be to create value from the asset granted without depleting it. At the top of the pyramid, as already specified above, we have the objectives and descending respectively strategy (operational planning) and operational KPIs.

Once the area to which the individual KPIs belong has been identified, the next step was to make the associations of the individual KPIs to the framework component of the reference process. It is possible for each macro-area to identify its framework elements, therefore each KPI must choose its unique framework element.

After the restructuring/systematization of the performance measurement system according to the asset management system processes, the possibility of updating the KPI database was then evaluated. Gap Analysis completes the work by comparing how a company should measure its management system performance, according to standard and best practice, and how it is currently evaluated in the organization.

Below is presented an example of the simulation of the KPI distribution on AM Framework components for the railway infrastructure manager examined in this work. Each colors indicate a different company's areas of responsibility. Figure 4

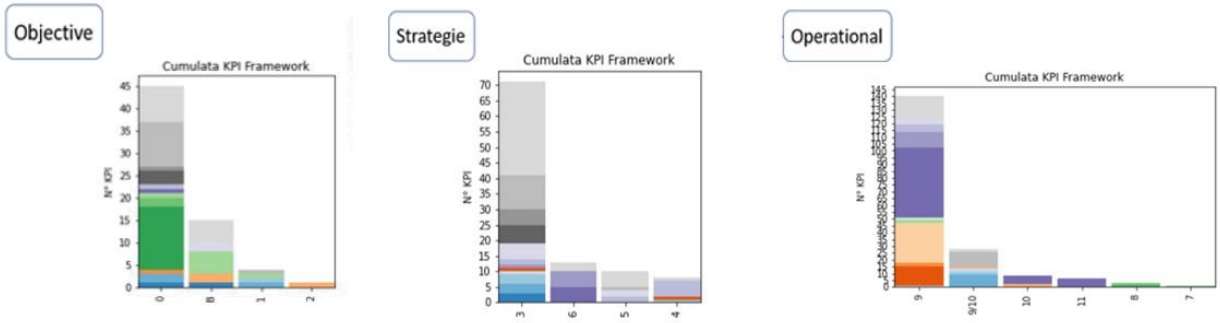

Figure 4. KPI distribution on AM Framework components

5.1 Proposed Improvements

Particular attention was given to the category of KPIs in the field of Sustainability: Environmental Social Governance (ESG), a theme considered central in this era. In addition to traditional perspectives, the most innovative are environmental and social aspects, with the aim of giving a coherent answer to the following questions:

- What is the value of environmental management and corporate social responsibility?
- How can companies plan and control the implementation of their sustainability strategy?
- How does this contribute to core business processes?

It's possible to think on a balanced scorecard [14] that favors and optimizes behaviors in line with the principles of environmental compatibility, first of all considering the company as a set of causal relationships between four interconnected visions (financial perspective, training and innovation, knowledge of customer and internal processes), and then assign a weight to intangible resources, which, although not immediately quantified in money and therefore not directly controllable with traditional management systems, play a fundamental role in determining a successful strategy for modern enterprise.
The Sustainability Balanced Scorecard aims to further expand the aforementioned vision by studying the integration of the environmental and social component within the system and assessing its contribution to the creation of value for the company, according to the three dimensions of sustainability:

- economic;
- social;
- environmental.

What is more, another key element that can act as a connector between strategical objectives and objectives delivery could be the value framework, a tool that declines the asset management system value elements that are connected to sustainability.

6. Conclusions

The use of the correct KPIs allows companies to highlight performance and sectors that need attention and improvement. In this study the key indicators were placed in the optimal management systems for the research of the value of a specific company, examining at first an optimal management system, as specified by the ISO standard of AM and then in a railway infrastructure management system, as specified by the guideline "UIC Railway Application Guide - Practical implementation of Asset Management through ISO 55001" - November 2016.

It was also possible to deduce that the KPIs definable are various and therefore it is very important to be clear about the use made of them in order to guide the improvement actions resulting from performance.

The development of KPIs starts from knowing the goal to achieve: they must provide information and answers to what is needed. The ability to define and correlate them provides the tools for quick analysis and effective decision making. The indices in use are therefore analyzed to understand the real use, any redundancies or uncovered areas.

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Biography

Rossana Coccia is Ph.D student in Industrial and Management Engineering, Sapienza University Rome. Her research activities are based on methodologies for the evaluation of infrastructure assets based on data analysis and BI.

Alessandro Corsini is Full Professor, Department of Mechanical and Aerospace Engineering, Sapienza University Rome. The scientific research activity has developed since 1991, without solution of continuity. The researches carried out followed different fields of study in the field of energy systems and the fluid environment and machines, and have been carried out within academic realities and research institutions national (i.e., COFIN, ENEA, CNR), and international (i.e., collaborations with DLR, Leicester University (UK), Rice University (USA), BUTE (HU), & e). A significant part of the work was then carried out in the context of industrial research programs and applied with the collaboration of leading operators in the energy and industrial machinery sector (i.e. Enitecnologie and ENI Spa, Faggiolati Pumps Spa, Fieni Sri, Flakt Woods Ltd, Flakt Solyvent AB, Flakt Solyvent Ventee & e) or at the service of public administrations and ministerial bodies (i.e. Provincia e Municipality of Latina, Ministry of the Environment and Land and Sea Protection, & e).

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GianPiero Pavirani Electronic engineer that in 1973 was hired by Ferrovie dello Stato, then RFI, gaining experience in operations management on infrastructure systems, design, Bologna Compartmental Management, with, in particular, experience in the design of signalling systems. After 5 years, he moved on to deal, again in the Bologna Compartment, with planning, control and improvement of maintenance in the compartment. Collaboration with the Rome Headquarters for the revision of business processes with the introduction of the railway infrastructure management system supported by ERP (enterprise resource planning) information systems. National Head of 'Maintenance Engineering' at RFI, providing design, control and improvement of maintenance processes for the entire company. Launched the Asset Management structure in RFI. Participated, as RFI representative, in the WG AM of the UIC.

Donatella Fochesato is Civil and Construction Engineer and she is currently in charge of the Asset Management Department of RFI. She has been working in the railway sector since 1998. She had a role as project engineer of the high-speed lines and related nodes in the context of the related orders. She contributed to the implementation of the Asset Management principles and the governance tools within RFI since 2016. She is a member of the UIC Asset Management Working Group.

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