How to use reliability engineering, degradation status and risk management to define strategic planning

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Overview

- The AM of a railway network: an integrated system
- The process of maintaining a railway infrastructure
- An application supporting reliability analysis and risk assessment of a railway infrastructure.
- The use of the data of the degradation of infrastructure
The AM of a railway network: an integrated system

Assets Management includes all the systems, methods, processes and tools to optimize costs, performance and risks during the whole life cycle of railway infrastructure.

The goal is to achieve the best value for money, such optimizations should cover all infrastructure activities (construction, maintenance and renewal, including construction machines, machines and materials) for the life cycle.

Requirements:

• to know what are the requirements of the parties concerned regarding maintainability, availability and reliability. In order to specify the realistic requirements, assets performance are determined in terms of Key Performance Indicators, trend analysis, etc.; moreover, adequate maintenance systems should be realized and maintained to manage all the activities;

• the asset Manager must be able to perform risk analysis for maintenance planning;

• must be established a method of maintenance management that takes into account the different aspects of cost / risk / revenue, in the different scenarios considered, taking into consideration the maintenance activities, the frequencies of maintenance, inspection frequencies, etc…
Overview of maintenance process support tools

Planning
- Cycle Maintenance plan:
- Legal inspections:
- on condition;
- predictive;
- ameliorative;
- corrective;
- extraordinary.

Programming
- Quarterly
- Weekly
- O.d.I./MTW

Scheduling
- Economical Control

Execution
- Technical control

Materials
- purchasing materials
- Contract Management
- Goods acquisition
- Store Management
- Delivery Management

Internal Shops
- MRS (Management Resource Scheduling)

Dashboard

Evolved Information
Maintenance System

Inframanager
- TE, LV, IS, TLC

Meridium
- Skills Maintenance

Network Model
- Training
- Interruption
- Speeds Shut down

Standard Activities
- Network Model
- Skills Maintenance

Maintenance assets
- Network Model
- Skills Maintenance

Installations conditions
- Network Model
- Skills Maintenance

Diagnostics
- Failure Warning
- Diagnostica
- PC 5000

List of material and suppliers
- Network Model
- Skills Maintenance
To locate correctly objects in the model taking in account their hierarchy and mutual dependencies is necessary a good functional location code, able to ensure flexibility in case of organizational changes.
Objects and their representation

**First Level**: Foligno station

**Second level**: Group of tracks in Foligno station

**Functional Location code**

Every object should be represented into the system by an univocal code; The functional location code should be a speaking code giving information about the hierarchical level of the object.
Objects and their representation

**Third level:**
The first odd running track in Foligno station

**4th level:**
Group of switch under the first odd running track in Foligno station

**5th level:**
First switch under the first odd running track in Foligno station
### Basic Data

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An application supporting reliability analysis and risk assessment of railway infrastructure

To execute the reliability analysis on railway infrastructure environment, needs a link to an platform that is able to handle millions of technical assets, each of which queried in detail in turn for numerous technical Characteristics. This software package are already used in industry worldwide, but for the first time was customized for the management of railway infrastructure in such way:

• full integration with the enterprise information system (SAP PM);
• data interface with the DB management with daily data extraction;
• guarantee the consistency of data from processes maintenance established for more than 10 years.

The system for managing asset performance (APM), RFI has customized specifically two modules:

• “Reliability Analytics”
• “Asset Strategy Management (ASM)”. 
Reliability Analytics: Bad actor analysis

Before starting any type of analysis, it is appropriate to analyze which technical objects in exercise, for a defined period of time, have highlighted problems both as regards the number of failures both as regards the subjections caused to rail traffic.

The Tool has a feature natively "Bad Actor", through which all objects appear more critical to analyze.
Reliability Analytics: Detection of the most critical families

The 6 basic rules for the construction of families of technical objects

Critical family of type of switch box on the main trail
Bad Actor: critical failure mode

Taking into consideration this family (switch box), we are going to deepen the failure modes the most critical:
Also on the selected family, let's make an analysis of the trend growth to get to know the family in recent years:

The analysis shows a good 'Goodness of Fit' and a $\beta$ value close to 1. You may then proceed to the failure mode "bad contact" analysis of distribution (Weibull).

You can make the first evaluations on the effectiveness of maintenance policies, noting that their application has given a trend led to an increasing MTBF equal final at 1494 days. (This value should be compared with respect to the target value)
Reliability Analytics: Reliability distribution analysis

Distribution Analysis:
- Family of objects useful life
- MTBF = 1512 days

Plot della Funzione Densità di Probabilità

Grafico Funzione Distrib. Cumulativa

Distribution del Tempo a cassa
- Tipo Distribuzione: Weibull
- MTBF: 1512,03 gg
- Beta = 1,0108, Eta = 1518,7896, Gamma = 0,0000

Grafico Probabilità

Plot del Tasso di Guasto

Distribution del Tempo per Riparazione
- Tipo Distribuzione: Lognormale
- MTTR: 0,81 Ore
Once we recognize the phase of the life cycle you can have some indication of best practices to adopt. A first analysis is performed on the entire sample of family failure and the results are compared with a value of reliability goal.

According to the difference detected between measured reliability and reliability goal is possible to understand the scope for improvement achievable through the review of maintenance policies.

Subsequent analysis are designed to determine the probability of failure referring to the critical failure modes. These values are then used in the module Asset Management Strategy for the construction of risk matrix. If reliability goal and reliability are consistent, can finally proceed to the extraction of the probability of failure in time by setting a target operating time.
The second module that RFI has configured, allows you to associate each mode of critical fault the level of risk calculated according to 3 different views (safety, regularity, financial).

The ASM module is therefore the tool for the management and optimization of maintenance policies through the analysis of risk maintenance, allowing to reduce the risks associated with the different failure modes related to a family.

For each critical failure mode it is necessary:

- to define level risk;
- to join to the level risk each currently used actions and to define their level action mitigation on the relative risk;
- to identify and propose new actions or modifications to ensure acceptable levels of risk. Unmitigated

The process can be activated in front of two different needs:

- to review the standard activities related to a specific family of objects considered “sensitive” in the previous preliminary reliability analysis;
- to identify the priorities for action to address a critical issue.
1. *Selection of risks to be analyzed.*

Referring to the preliminary reliability analysis carried out, you select the critical failure modes, the main subject of risk analysis, considering for each failure mode its probability of occurrence and the specification impact.
2. **Unmitigated risk calculation for each failure mode.**

Strategic analysis of risks is based on a common methodology for the quantitative assessment through the use of matrices giving the failure mode identifying the level of **probability of occurrence** and the **level of consequence** that it generates. The level of probability of occurrence is chosen according to a classification based on 5 levels. Once these parameters will be defined, the risk inherent in each single failure mode will be calculated.

Set the level of probability of occurrence, is then defined the level of consequence, also based on 5 levels. The product of the probability of occurrence and the **impact** determines the risk, that allows to have a scenario of such failure modes appear to be more critical and which failure mode appears to have priority of intervention.
3. Definition of levels of mitigated risk by each maintenance activity for each failure mode. The last step will be the allocation for each asset maintenance standards in use, the level of risk mitigated, then measuring the impact that each activity has on the specific standard critical failure mode according to the category of risk considered. Finally, once defined the mitigating actions, the next steps will focus on the definition of mitigated risk by a similar procedure to that mentioned above in the unmitigated risk level definition.

e.g. Subsequently be assessed maintenance activities (tasks) mitigating the risk ‘bad contact’, indicating, for each task and for the views, the level of impact and risk mitigation in respect of:
Asset Strategy Management (ASM)

- Selecting the critical failure modes
- Attribution of risk level
- Evaluation of proposals to modify
- Proposal for changes to the standard activities
- Revision of risk levels
- Attribution of risk mitigated

The objective is to make the maintenance cycles always more consistent and dynamic compared to the operational context.
The use of the data of the degradation of infrastructure

Data processing gives the opportunity to easily provide a huge amount of data thus improving the information and decisions quality and this imposes the need to employ data safely.

The main risk is that an “excess of data” may lead to waste time and obscure information.

Data is important since it gives information, thus contributing to comprehend the situation.

“It is necessary to turn data into information”
From data (diagnostics) to activity (maintenance)

1. Identification of main parameters
2. Definition of reference thresholds
3. Measurement and data organization
4. Deviation from the thresholds
5. Identification of maintenance interventions
Once the reference values are defined, it is necessary to know the admitted thresholds of these parameters and to define the maintenance approach according to the degree of non-conformity. Different thresholds have been identified: the thresholds define the behavior according to the deviation from the reference value:

- warning;
- intervention
- deceleration
- interruption.
Planning and Programming: Inframanager

Advanced tool of analysis of the Data and it turns them into useful Information to the activity of the Planner:

- It individualizes and proposes the correct activities
- It individualizes and proposes the priorities
- It optimizes the interventions rationalizing the resources

Through algorithms, elaborated from the experts and in tuning with the technical legislation, that they keep in mind of all the fundamental technical parameters,

The tool activates an efficient and effective maintenance rules → The policy of maintenance
Analyses data with rules: activities

Rules are applied on segments which are homogeneous track sections as for deterioration (200 m of track, run track, automatic adjustment, etc.)

IF * THEN Activity XXX

IF AND WHEN * THEN Activity YYY
The degradation: predictive analysis

Intervention threshold

Warning threshold

Scheduling date

IQB

Maintenance activities

Sept 2010

Jan 2011

May 2011

Nov 2011

Sept 2010

Jan 2011

May 2011

Nov 2011