A SUSTAINABLE PROCESS TO CONTROL THE RAILROAD TRACK STRUCTURE

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ABSTRACT

The results observed in the last five years demonstrate that the growth potential of the Brazilian freight and passenger railroad sector is substantial, with the railroad companies conquering prominence due to the importance of their services in the country logistic. This transport production growth submits to the track structure large load requests that contribute to speed up the degradation of its components, being essential its maintenance. This maintenance, besides preventing the track collapse, assures the desired level of service. The concern to adequate the railroad operation to sustainable transport rules could be eased of with the development and application of appropriated methodologies. In this direction the Reliability Centered Maintenance (RCM) appears as an option.

The purpose of this paper is to present the environmental impacts associated to the failure of the components of the track structure. To reach this objective, the method Failure Modes, Effect and Criticality Analysis (FMECA) incorporated in the RCM, will be used.

1 INTRODUCTION

The Brazilian freight and passenger railroad sector evolved during the century XIX, practically due to Brazilian governmental incentives. Eventually, private incentives were seen. However, the development of the sector was still unsatisfactory. The main factors that contributed for this retraction were:

- Brazilian governments incentives were applied mainly to roadways
- Brazilian economic model depending on external markets, produced periferic nets isolated and convergent to the littoral.
- Logistic problems like:
  - inadequate or critical large number of crossing;
  - railroads field side invasion;
  - impropriated accesses to the main Brazilian ports;
  - difficulties to access main metropolitans regions;
  - deficient traffic shared rules.

In an attempt to reheat the Brazilian freight railroad sector, the Brazilian government decided in 1996 to start the railroads privatization process. With this, the participation of the railroad in the cargo
transport matrix increased from 17%, in 1997, to 25% in 2005, presenting, in this period, a substantial growth in its productivity, as it is shown in FIG. 1 (ANTT, 2006; ANTF, 2006)

![FIG. 1: Railroad Load Transports Production in Billions of TKU (ANTT, 2006, ANTF 2006)](image)

Even though the Brazilian rail net density is still very low when compared with other countries (TAB. 1).

<table>
<thead>
<tr>
<th>COUNTRIES</th>
<th>EXTENSION (km)</th>
<th>TERRITORIAL AREA (km²)</th>
<th>RAILROAD DENSITY (km / km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERMANY</td>
<td>47.201</td>
<td>349.223</td>
<td>135,2</td>
</tr>
<tr>
<td>ENGLAND</td>
<td>17.156</td>
<td>241.590</td>
<td>71,0</td>
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<tr>
<td>JAPAN</td>
<td>23.556</td>
<td>374.744</td>
<td>62,9</td>
</tr>
<tr>
<td>FRANCE</td>
<td>29.085</td>
<td>545.630</td>
<td>53,3</td>
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<tr>
<td>UNITED STATES</td>
<td>226.605</td>
<td>9.161.923</td>
<td>24,7</td>
</tr>
<tr>
<td>ÍNDIA</td>
<td>63.230</td>
<td>2.973.190</td>
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<tr>
<td>ARGENTINA</td>
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<td>CHINA</td>
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<td>AUSTRALIAN</td>
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<td>CANADÁ</td>
<td>48.467</td>
<td>9.093.507</td>
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<tr>
<td>BRAZIL</td>
<td>29.252</td>
<td>8.456.510</td>
<td>3,5</td>
</tr>
</tbody>
</table>

(Adapted by authors from CIA The World Factbook, 2006)

With respect to the Brazilian passenger railroad sector this grew 8% in 2006, more than the average value of 3% verified in 2005. Among the urban operators it can be mentioned the subway of São Paulo City that went from 2.1% in 2005, to 9.9%, in 2006 (REVIEWED RAILROAD, 2007, p. 59).

But also this sector still presents a low participation in the Brazilian transport matrix, when compared with buses and cars (TAB. 2) (ANTP, 2007).
The railway transport increment obtained in the last years for cargo as well as for passengers directly influences the useful life of the system and compromises the track structure due, mainly, to the movement of the rolling stock. Being so, effective control practices are to be planned and applied periodically to avoid or to reduce environmental impacts.

2 OBJECTIVE

The objective of this research is to relate the environmental negative impacts to the failure modes of each of the components of the track structure, as a way to subside the Maintenance Engineering decision making process and to take into account the sustainability of this modal. To reach this objective, the method Failure Modes, Effect and Criticality Analysis (FMECA), incorporated to the Reliability Centered Maintenance (RCM) will be used.

3 THE TRACK STRUCTURE

The main functions of the track structure are to receive and to distribute the impacts derived from the circulation of the rolling stock, which allows certain level of quality to the transport of cargo and passengers services.

Before the structure reaches pre-established limits of tolerance to assure security and comfort, it has to be reviewed. These limits of tolerance depends the Rolling Stock speed, the freight axle, and the track structure characteristics, among other factors.

Being so, the track structure has to be studied in its components, namely rails, ties, ballast (sub ballast in some cases) and rail fixation accessories in order to associate possible degradations to negative environmental impacts (FIG. 2).
Variations of the track structure components can be detected from parameters that define the quality of the track geometric. Theses parameters are: Gauge, Longitudinal and Transversal Leveling, Horizontal Alignment, Warp and Super elevation. For each of these, standards or tolerances are fixed for each railroad manager (CANADIAN PACIFIC RAIL SYSTEM, 1996 apud RASP, 1998, p.30, BRINA 1979, p.234).

4 ACTIVITIES FOR TRACK STRUCTURE OPERATIONS AND ASSOCIATED ENVIRONMENTAL IMPACTS

According to FOGLIATTI et al. (2004, p.125), the activities that propitiate the railroad operation are related with the movement of the rolling stock, with the track structure conservation services, with track structure components substitutions, with the track structure geometric reconstructions, with the transport of dangerous products and with the operations performed in patios and terminals.

All these activities could provoke environment negative impacts under certain circumstances being necessary to apply measures to prevent bigger problems.

The track structure conservation services consist on field side and ditches cleanness services. The first one consists on the withdrawal of vegetation that grows along the line and it can be performed manually, with use of hoe, or with a chemical process, called, chemical weeding. The ditches cleanness service is carried through in order to prevent clogging and destruction of the ditches.

The activities related to the track structure geometry reconstitution consist on the verification of the parameters that constitute the railroad geometry in order, to place the line as close as possibly to the condition of new, allowing a soft and safe circulation and reducing the number of accidents.

The track structure components substitutions consist of services to substitute ties, tracks and accessories when needed. To substitute those elements different equipments are used.

All these activities can generate environmental impacts, among which they can be mentioned: noise, air, water and soil degradation, accidents, discomfort, humans and animals alteration mood.
5 THE PROPOSER PROCEDURE

The purpose of this paper is to use the Failure Modes, Effect and Criticality Analysis method to relate the modes of failure of the track structure components to negative environment impacts.

5.1 MAINTENANCE PROCESS

The United Nations Organization characterizes the activities of any organized entity as "Production = Operation + Maintenance", giving to the maintenance the following responsibilities: to reduce the equipments unavailable times; to repair the equipments when irregularities that reduce their potential appear and to guarantee that products and services be performed under pre-established quality standards (TAVARES, 1997, p.1 apud SUCENA, 2002, p.102).

The maintenance concepts, as well as their purposes evolved following the world-wide industrial development, as shown in FIG. 3 (SIQUEIRA, 2005, P.4).

![FIG. 3: Maintenance Evolution](image)

The corrective maintenance has the objective to correct failures after they occurred. The preventive and detective maintenance have the intention to prevent and to search failures to act before they manifest themselves. The productive maintenance is used to optimize the process and the project of new equipment, and the Reliability Centered Maintenance has it focus in the equipments available time.

5.2 THE RELIABILITY CENTERED MAINTENANCE

As established before, the Reliability Centered Maintenance (RCM) process has, as main focus, the equipment available time and looks at failure consequences.

Being so this process looks for answers to the following six questions (SIQUEIRA, 2005, P.4):

1 – which functions are to be preserve?
2 - which are the functional imperfections?
3 - which are the failure modes?
4 - which are the failure effects?
5 - which are the consequences of the imperfections?
6 - which are other alternatives?
To answer question n.° 3, the technique "Failure Modes, Effect and Criticality Analysis" (FMECA) is used.

5.3 FAILURE MODES, EFFECT AND CRITICALITY ANALYSIS (FMECA)

The Failure Modes, Effect and Criticality Analysis (FMECA) technique has the objective to identify all the ways each of the components of a system would fail and to evaluate the effects those failures would have on each component and on the general system (SIMÕES SON, 2004).

The FMECA technique is a logic process that from an undesirable and pre-established event searches in a tree structure all possible causes.

It was created from a basic model developed by the USA Army Force in 1949 and it is allows to present from high cost modifications or substitutions.

Some of the steps of this technique usefull for this work are:

- System description enforcing operational functions of each of the components that constitute the system;
- Identification of each component failure modes;
- Identification of failures causes;
- Determination of the expected effects;
- Established of mitigating and correcting measures for each failure mode.

The main advantages of such technique are that it allows to understand all the technical equipment characteristics on to understand a given phenomenon.

5.4 PROCEDURE TO RELATE COMPONENTS TO ENVIRONMENT IMPACTS

The procedure proposed to relate each track structure component failures to negative environment impacts follows the stages displayed in FIG. 4.

FIG. 4: Process Stages
CONCLUSIONS

The main objective of the Reliability Centered Maintenance is to improve the reliability in the level service of the system under analysis. Its use to associate failures of track components to negative environment impacts makes possible the adequacy of the railroad system to the sustainable development concepts.

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