A case study on Brazilian Regulation of Railroad Accidents and Incidents: Focus on Different Regulations Around the World, the Evolution and Impacts of Brazilian Regulation

International Certification in Management of Rail and Metro Rail Systems

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Summary:

The regulation of Brazilian railroads began in the 1990s, during the privatization process of the main public freight railroads. These concessions had only two KPIs to ensure the execution of the contracts for what is still considered a public service (traffic movement and railway safety). In the following decades, the regulation revised the process of investigation and communication of accidents with the need for more and more information to be sent to the Regulatory Agency, creating a more complex regulatory process for both parties.

Different economic regions around the world report and control rail safety in different ways. The FRA, the U.S. Railroad Administration, for example, classifies an accident according to its monetary impact. The ERA – European Union Agency for Railways – through several National Investigation Bodies (NIB) investigates only serious accidents that reach a certain level of social and financial impact (fatalities, serious injuries or damage above a certain monetary value) and/or those that, depending on circumstances, would become serious.

The objective of this work is to investigate the different parameters of the regulation of these three economic blocks (Brazil, USA and EU), evaluating their regulatory burden, as well as to analyze the new Brazilian railway legal framework (Law nº. 14,273/2021), in which accidents that are not directly caused by a train operation should not be accounted for in the KPIs of its regulator.

Keywords: Regulation, Freight Railroads, Investigation, Communication, Accidents.

Summary:

List of Figures:

List of Abbreviations:

ANTT – Agência Nacional de Transportes Terrestres.

ANTF – Associação Nacional dos Transportadores Ferroviários.

ART – Anotação de Responsabilidade Técnica.

CCO – Centro de Controle Operacional.

CREA – Conselho Regional de Engenharia e Agronomia.

IAF – Índice de Acidentes Ferroviários.

IML – Instituto Médico Legal.

GECOF – Gerência de Fiscalização de Infraestrutura e Serviços da SUFER/ANTT.

SUFER – Superintendência de Transporte Ferroviário da ANTT.

1. Introduction

Railway safety is a day-to-day issue for any railway operator. The greater the safety in rail operations, the greater the transportation performance, which is why the operators invest so much in this issue.

Currently, the Regulatory Agency has resolutions in place that define rules for classifying and reporting rail accidents, as well as parameters to be considered when stating safety targets based on the total number of accidents divided by the distance covered by rail transport.

One of the points of discussion is the fact that current regulations do not provide for accidents to be recorded separately by cause, for the purposes of measuring compliance with safety targets.

Currently, rail accident data already shows the need for a differentiated assessment due to the sharp drop, since the initial concessions in the 1990s, in accidents caused by technical causes (directly linked to rail operation and the control of the concessionaire) and the stagnation, or slight increase, in accidents caused by third-party interference (vandalism, suicides, third-party disrespect for signaling on grade crossings, trespassing, etc.), most of them being difficult, for operators to control, even considering all the actions and investments already made.

In this sense, it is important to review Brazil's regulations on rail accidents and incidents, observing international practicies as a another practices, considering their impacts on the sector and with the objective of making regulatory treatment more efficient with a standpoint of achieving net results that could lead to a reduction of accidents.

The hypothesis considered in this work is that segregating accidents in terms of third-party and technical causes, assigning different forms of monitoring and regulatory consequences for each case, can guarantee more intensive investment in proactive and risk-mitigating measures and, consequently, a reduction in accident rates caused by third-party interference in railway operations, reducing the regulatory burden without impacting the quality of the accident rate control process.

The next sections present a national context regarding the history of accidents on Brazilian rail networks and their current regulatory context. This is followed by an international review to investigate the different accident regulation parameters in three economic blocks (Brazil, the USA and the EU).

Finally, guidelines are presented for the development of a new regulation, with segregation of accidents, their monitoring and the composition of safety targets according to the main cause of the accident ("external or third party origin" and "internal or technical origin").

2. Brazilian National Context

2.1 Regulatory and Legislative Framework

ANTT Resolution No. 5,902, of July 21, 2020, defines a rail accident as "an occurrence that, with the direct participation of a rail vehicle, causes damage to it, to people, to material goods, to the environment and, as long as traffic is stopped, to animals".

In addition, according to ANTT Resolution 5902/2020, rail accidents can be classified according to their nature (hit-and-run, collision, collision between rail vehicles and with an obstacle, derailment, explosion, fire and others) and the cause (interference by third parties, human factor, management, systems, rolling stock, tracks, act of God or force majeure and others).

A train accident will be considered severe when it involves at least one of the following:

- Death of a person at the time of or within 30 days of the accident;
- Person hospitalized for more than 24 hours as a result of the accident;
- Passenger transportation by rail (even in the absence of death or injury);
- Degradation of environmental quality or pollution;
- Transportation of dangerous goods by rail (even if there is no product spillage);
- Damages more than R$ 2,220,000; or,
- Interruption of traffic on a segment of track for a period of more than 2 hours (lines shared with the urban passenger service), 6 hours (lines shared with the long-distance passenger service) and 24 hours (lines exclusively for freight transportation).

Currently, given the existing regulations (Resolutions 5.902/2020 and 5.831/2018), all rail accidents[1] are considered in the same way, regardless of the cause. For the calculation of the Rail Accident Index (IAF) and, consequently, for the verification of the safety targets of the respective concession contracts. If the target is not met, the concessionaire is penalized with a fine and even an early termination for their concession contract.

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The investigation is carried out by the concessionaire who, in accordance with the rules established by ANTT Resolution 5.902/2020, must provide the Regulatory Agency with information about the rail accident, identifying the type of accident, its cause, among other information, in addition to submitting a report with a technical report on the investigation.

2.2 Intra company accidents investigation

In most of the companies, accidents are investigated to mitigate and avoid future accidents of the same cause. All accidents are submitted to an internal investigation team, that independently files a report.

This technical report involves all the technical areas of operations, tracks and rolling stock in an effort to collect all the data from the site, such as:

- Mapping and layout of the incident with reference points, distances and locations of the assets involved;
- Measurements of the assets (tracks and rolling stock) involved to check parameters and understand the mechanism of the incident;
- Taking statements (train driver or people who saw what happened);
- Collecting the train conductor's driving and operating records;
- Historical data from the assets and location.

Once this data has been collected, a full historical assessment of the assets is added to understand whether there was any past interference that may have affected them, as

[1] Only accidents caused by a rail vehicle colliding with a corpse are disregarded, provided that the concessionaire can prove that the corpse died before the accident (autopsy report issued by the IML).

well as to understand whether previous inspections and checklists were carried out in order to compare them with the data collected in order to understand the cause.

With all this data, a multidisciplinary technical team evaluates the mechanism of the occurrence in an accident investigation committee and identifies all the corrective, preventive and replication actions for other sites.

The governance of these actions is carried out at a periodic meeting, which assesses not only compliance with the actions, but also their effectiveness in blocking the root cause.

Evaluating the actions from an effectiveness point of view, dealing with incidents involving third parties ends up being dealt with in isolation, being an issue, as stated above, that involves several players in order to actually be an effective cultural change action.

The safety targets are set every five years, with the possibility of an annual review, where the upper acceptable limits for the IAF are defined, considering the total number of accidents and the total distance traveled (train x km). According to ANTT Resolution 5831/2018, the safety targets are proposed by the concessionaire and must consider an Operational Safety Study that includes the history and trend of accidents with the IAF since 2006, as well as the programs and actions that will be adopted with a view to improving the safety of rail operations.

Compliance with safety targets is measured annually using the IAF, and rail accidents are calculated and attributed to the concessionaire that caused them.

Recently, on 23/12/2021, Law No. 14.273, known as the Railways Law, was enacted, which provides for the organization of rail transport, the use of rail infrastructure, the types of concession for the indirect exploitation of railroads in the national territory, the urban operations associated with them, as well as other measures.

As for the traffic safety aspect, Law No. 14.273/2021, in its Article 49, sole paragraph, establishes that "Accidents and occurrences must be classified by the railway regulator as to severity, foreseeability and inevitability, under the terms of the regulations, which will also define the hypotheses of administrative liability of the railway operator".

It is therefore feasible that the current regulations should be revised, as now both the classification of the accident and the chances of the railway operator being held administratively liable must take into account that not only the severity and foreseeability, but also the inevitability of the accident, i.e. the operator's ability to avoid a certain type of accident, but be taken in consideration.

Finally, Law No. 14.273/2021, article 56, establishes that "the railway operator must keep a record of accidents that occur on its lines, workshops and other premises, indicating the probable causes and the measures taken, including those of a preventive nature, the content of which must be shared with the authorities that request it". In other words, regardless of classification, severity and administrative responsibility, the operator must keep a record of rail accidents.

2.3 Figures from the Brazilian Railway Sector

After the start of the Brazilian concessions (1996), there was a significant drop in the number of rail accidents and, consequently, in the IAF, since there was also an increase in rail productivity (train x km).

The following graph shows the behavior of the Rail Accident Index - IAF over the period from 1997 to 2020, based on data from ANTF (1997 to 2006) and data extracted from the Rail Transport Monitoring and Inspection System - SAFF/ANTT (2006 to 2022).

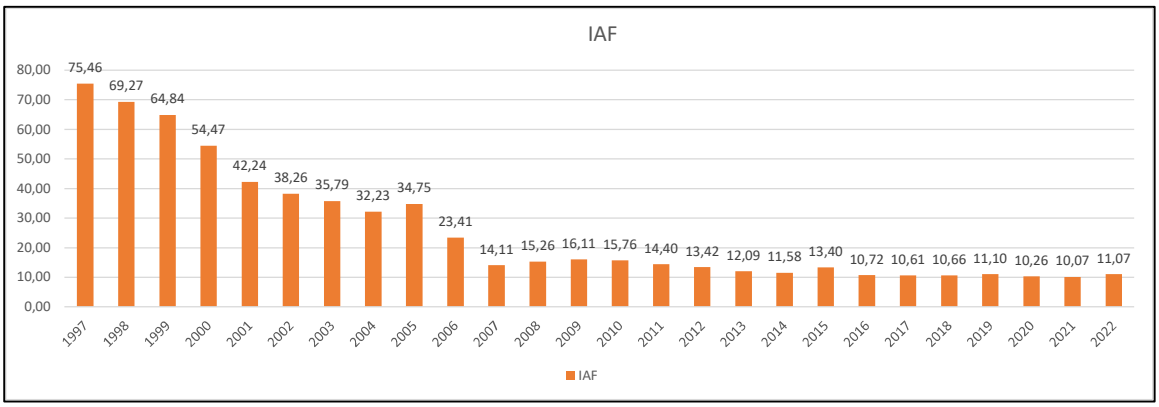

Figure 1: Behavior of Rail Accident Index – IAF between 1997 and 2022 (Source: SAFF/ANTT e ANTF).

One can immediately see the significant drop in the IAF over the years, after the concession of the railroads, with the year 2021 recording the lowest IAF of the entire concession period (10.07 accidents per million train x km).

At the same time, the following graph shows that this drop occurred in an environment of growth in rail transport, when comparing the Number of Accidents (in decline) with the Distance Traveled (Train.km), which represents the sum of the route of all the trains formed in the period.

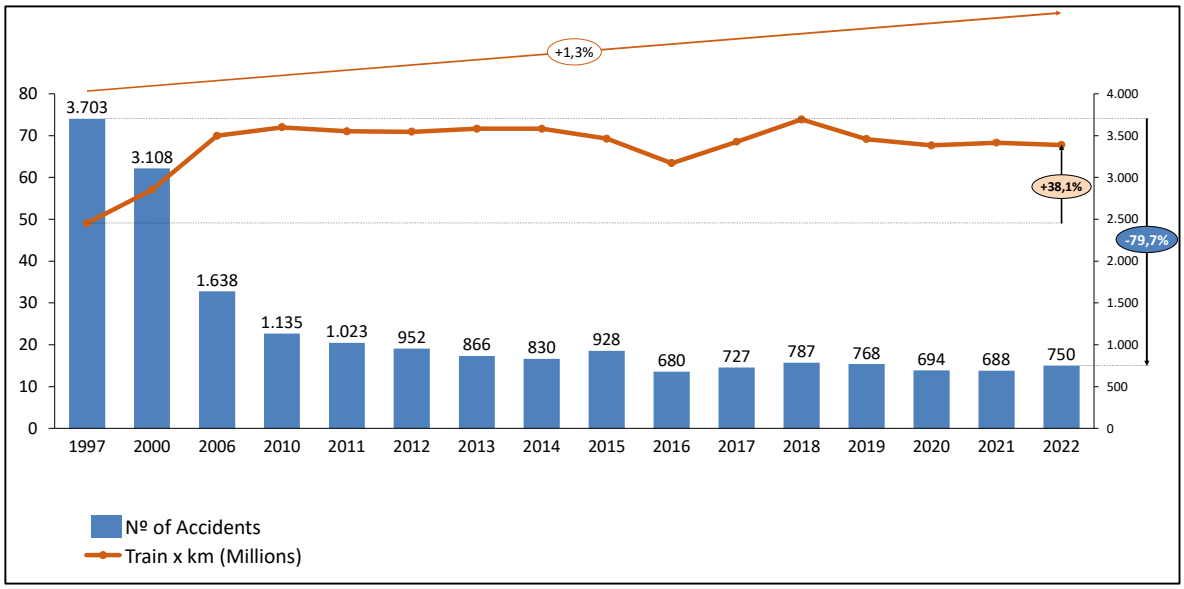

Figure 2: Number of accidents x millions of trains.km between1997 and 2022 (Source: SAFF/ANTT e ANTF).

Even with all this reduction in the number of accidents, largely due to the investments made by operators and actions/campaigns to mitigate and raise awareness among the local population, there has been a change in the profile of accidents in recent years.

Currently, the majority of rail accidents are caused by factors outside the direct control of the concessionaire. In 2022, around 70% of accidents may have been caused by third-party interference (vandalism, collision and being run over) and 43.3% of all accidents in 2022 (750) occurred at grade crossings.

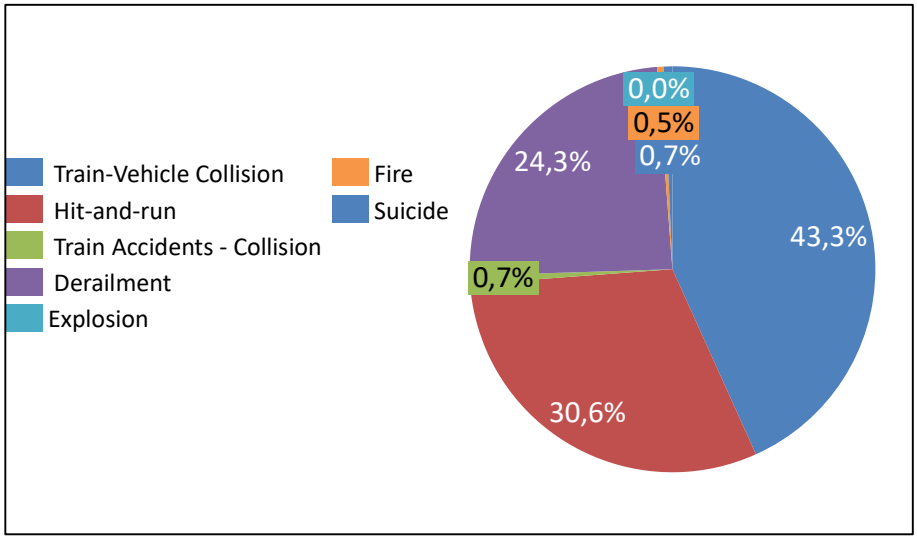

Figure 3: Railway accident classification in 2022 (Source: SAFF/ANTT).

These figures will be described in more detail below, when describing the proposal to segregate accidents according to their cause.

3. International Review

To help draw up the proposal, we sought not only to analyze the Brazilian scenario, but also to evaluate international references for accident reporting processes, the investigation of occurrences, control and the possible definition of targets and penalties. The survey of international references focused on case studies in the United States and Europe.

3.1 United States of America

Regulations on the subject are contained in Title 49 of the CFR (Code of Federal Regulations), part 225 - Railroad Accidents/Incidents, Reports Classification and Investigations, which defines railroad accidents as follows:

- Train Accidents: collisions, derailments, fires, explosions, acts of God or any other event involving the operation of railway equipment on the track (stationary or in motion) that results in damage greater than the current threshold established for accidents that must be reported[1] ;
- Train Incidents: any event involving the movement of equipment on the track that results in reportable occurrences, but in damages less than those established for classification as accidents;
- All accidents/incidents occurring at highway-rail grade crossings (Grade Crossings - PN), with railway equipment and which cause deaths, injuries or occupational illness must be reported, except:
    - Accidents/incidents that do not involve the operation of railroad equipment or the presence of railroad employees engaged in the operation;

[1] This limit is calculated based on two parameters (average salaries of railroad maintenance workers and a general cost index for railroad equipment), and is updated annually, taking into account the value and parameters established the previous year.

- Derailments caused by persons other than railroad employees or by vandalism and;
- Among others reported in section 225.16 of Title 49 of the CFR.

Thus, rail accidents that must be reported are divided into three groups: i) accidents on the PN; ii) accidents with railway equipment; and iii) death, injury and occupational illness.

There are three bodies that carry out the investigation, but not all accidents are investigated by the three parties:

- Regulatory Agent: Federal Railroad Administration (FRA);
- Independent Institution (Investigative Agency): National Transportation Safety Board (NTSB);
- Operator itself (each operator must adopt and comply with an Internal Control Plan in accordance with Section 225.33, Title 49 of the CFR).

The concessionaire must report the accident within 24 hours and the FRA audits the operator's investigation, delivered in a format already defined. If the operation is found to be compliant, the operator is not penalized.

In accordance with Section 225.31, Title 49 of the CFR*: "It is the policy of the FRA to investigate rail transportation accidents/incidents that result in the death of a railroad employee or the injury of five or more persons. Other accidents/incidents are investigated when such investigation substantially serves to promote railroad safety."*.

The FRA establishes safety standards for different assets and procedures, with those related to track being adjusted according to the class of railroad. In addition to auditing operators' reports, there are also physical inspections by federal agents and third parties.

The data can be obtained from database queries on the FRA website (https://safetydata.fra.dot.gov/officeofsafety/publicsite/query/TenYearAccidentIncidentOverview.aspx) and categorized according to the type and consequence of the accident, region, type or group of railroads, among others.

Category
Number of railroads included
TOTAL ACCIDENTS/INCIDENTS 1/
..... RATE of Total Acc/Incs per mil train miles
--- Total fatalities
--- Total nonfatal conditions
--- Employee on duty deaths
--- Nonfatal EOD injuries
--- Nonfatal EOD illnesses
--- Total employee on duty cases
--- Employee hours worked
..... RATE of Employees on duty per 200K hours
--- Cases with days absent from work
--- Trespasser deaths, not at HRC
--- Trespasser injuries, not at HRC
--- Trespasser Incidents, not at HRC
--- Passengers kld in train accs or crossing incidents
--- Passengers inj in train accs or crossing incidents
--- Passengers kld in other incidents
--- Passengers inj in other incidents
--- Passengers transported
--- Total train miles
--- Yard switching miles

TRAIN ACCIDENTS (Not at Grade-Crossings)
..... RATE of Train Accidents per mil train miles
--- Train accident deaths
--- Train accident injuries
--- Human factor caused
--- Track caused
--- Motive power/equipment caused
--- Signal caused, all track types
--- Signal caused, main line track
--- Miscellaneous caused
--- Collisions
------- Collisions on main line track
--- Derailments
--- Other types, e.g., obstructions
--- Train accidents on main line 5/
..... RATE of Train accidents per mil train miles
--- Accidents on yard track
..... RATE of yard accidents / yard switching miles
--- HAZMAT RELEASES
--- Cars carrying hazmat
--- Hazmat cars damaged/derailed
--- Cars releasing

--- Cars carrying hazmat
--- Hazmat cars damaged/derailed
--- Cars releasing
--- Accidents with reportable damage over $100K
..... PERCENT of all train accidents
--- Accidents with reportable damage over $500K
..... PERCENT of all train accidents
--- Accidents with reportable damage over $1M
..... PERCENT of all train accidents
HIGHWAY-RAIL INCIDENTS
..... RATE of Highway-rail incidents per mil train miles
--- Highway-rail incidents deaths
--- Highway-rail incidents injuries
--- Incidents at public xings
..... PERCENT of total Highway-rail incidents
OTHER ACCIDENTS/INCIDENTS 3/
--- Other incidents deaths
--- Other incidents injuries

Figure 4: Railway accident categories (Source: FRA).

In recent manifestations (e.g. Technical Note No. 38/2018/COSEF/GEROF/SUFER/ANTT of 10/07/2018), based on processes to review

accident targets, the Regulatory Agency groups American data on Class I railroads into "Technical Nature" and "Third Party Participation" accidents, as highlighted below.

[7] Não foram considerados os dados de acidentes relativos ao transporte de passageiros (AMTRAK). Para segregação dos dados, foram considerados como acidentes de **natureza técnica** as ocorrências classificadas como "Trains Acidents - Not at Grade-Crossing", correspondentes às causas "Human factor caused", "Track caused", "Motive power/equipment caused", "Signal caused, all track types" e "Miscellaneous caused". Os dados correspondentes a acidentes com **participação de terceiros** foram obtidos pela soma das ocorrências classificadas como "Highway-Rail Acidents" e "Other Acidents/Incidents", excluídas as ocorrências relativas a empregados em serviço ("Employee on Duty Cases").
[8] Disponível em: http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Query/TenYearAccidentIncidentOverview.aspx (Consultado em 15/03/2018)

Figure 5: Technical Note Nº 38/2018/COSEF/GEROF/SUFER/ANTT.

Based on this segmentation, the following graph shows the historical behavior of rail accidents in the United States, where it can be seen that accidents involving third parties account for around 70% of all accidents, similar to what is seen in Brazil.

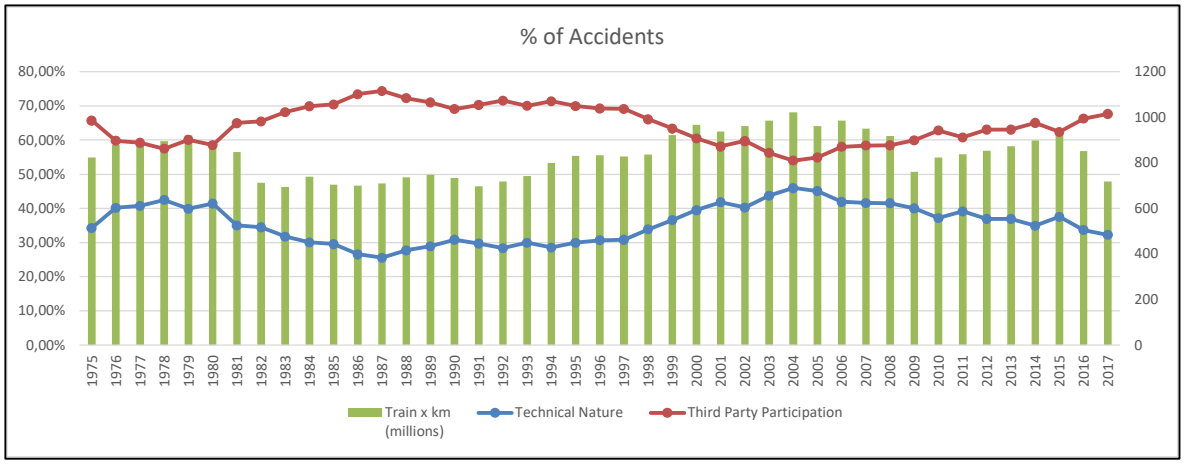

Figure 6: Graphic elaborated according to the data from the Technical a Técnica Nº 38/2018/COSEF/GEROF/SUFER/ANTT.

As detailed in the studies "Developing Intelligent Railway Regulation" and "Evaluating Railway Regulation", prepared by the Boston Consulting Group - BCG[1] , in the USA there are no accident targets but (a) the establishment of accident and incident parameters, segmented by "root cause" ("operator" and "other factors"); (b) the monitoring of accident indicators; (c) the issuing of a "warning" in the event of a deviation of the indicator from the determined standard; and (d) the imposition of a fine if there is no correction. The North American system is shown in the summary table below: [2]

[1] The Boston Consulting Group - BCG is a global management consulting firm with more than 90 offices in 50 countries, and is currently the world's leading business strategy consultancy.

[2] Source: BCG. In addition: https://railroads.dot.gov/railroad-safety
https://www.ntsb.gov/investigations/process/Pages/default.aspx

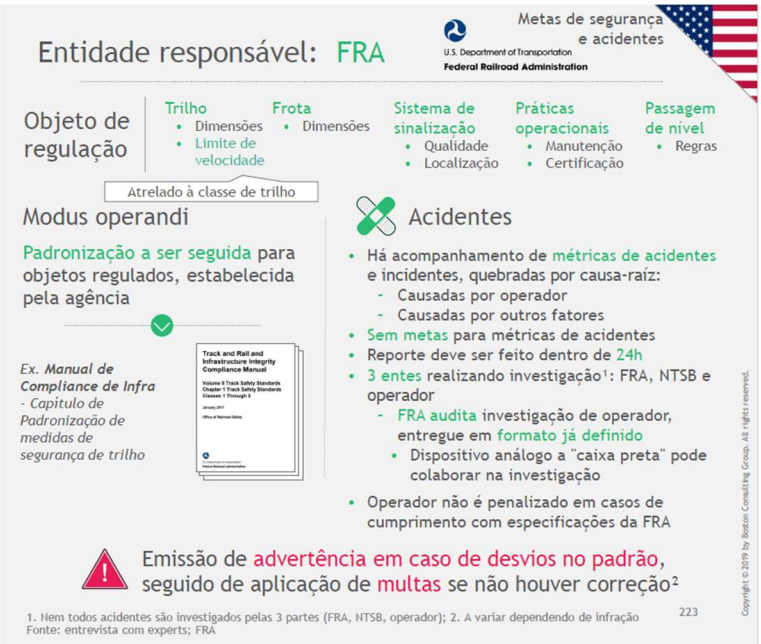

Figure 7: Accident process in USA (Source: BCG, 2020).

3.2 Europe

Among the various member states and independent agencies in the European Union, the European Union Agency for Railways (ERA) is one of the agencies that deals with transport with the aim of contributing to the integration of the European rail system, promoting a harmonized approach to rail safety.

Each Member State is obliged to establish independent National Investigation Bodies (NIBs). As the approach and methods for investigating accidents can vary between each NIB, ERA develops guides to assist in the development of guidelines on standard investigation methods, providing a platform for sharing good practices and offering customized services on request, such as training for railway accident investigators or assessments of investigation practices.

The principles for investigating accidents and incidents on the rail system in the European Union are established by the Railway Safety Directive (RSD) 2004/49/EC, which sets out guidelines for seeking common safety objectives, methods and indicators. It is based on these guidelines that the ERA has created the Guide to Guidelines for the Establishment and Work of NIBs and the Guide to Guidelines on the Investigation and Reporting of Railway Accidents and Incidents.

Article 3 of RSD 2004/49/EC defines:

> *"...k) "Accident" means a sudden, unwanted or unintended event, or a chain of such events with harmful consequences; accidents fall into the following categories: collisions, derailments, grade crossing accidents, accidents to persons caused by rolling stock in motion, fires and others;*
>
> *(l) "serious accident" means any collision or derailment of trains resulting in at least one fatality, or five or more serious injuries, or significant damage to rolling stock, infrastructure or the environment and any other similar accident with a manifest impact on railway safety regulations or safety management; "significant damage" means damage the cost of which can be immediately assessed by the investigating body to total at least EUR 2 million;*

(m) "Incident" means any occurrence, other than an accident or serious accident, associated with railway operation and affecting the safety of the operation;

..."

For the continuity of the review presented here, the results presented by GECOF/SUFER/ANTT[1] in the report "Report on the Exchange between ANTT and ERA - Railway Safety, 2018", the result of the exchange between ANTT and ERA between October 2017 and February 2018, were adopted as a reference. The aim of this exchange was to promote cooperation in the field of rail transport and the results presented come from the knowledge acquired from the traineeship program carried out at the ERA Safety Unit.

As already mentioned, each Member State has a National Safety Authority and a National Investigation Body.

The National Safety Authorities must be completely independent in their organization, legal structure and decision-making process from any railway company or infrastructure manager. Their competences are:

- Authorize the start of operations of new railway segments, signaling and energy systems;
- Authorize new vehicles for circulation within national limits;
- Support ERA in issuing authorizations for vehicles to be used in more than one Member State;
- Supervising interoperability requirements;
- Issuing safety authorizations to infrastructure managers and supervising them;
- Issuing safety certificates to railway undertakings and supervising them;
- Monitoring compliance with safety rules and, if necessary, updating them.

The National Investigation Bodies carry out accident investigations and must also be independent in their organization, legal structure and decision-making process from the railway companies and also from the national safety authority, as cited in the Exchange Report mentioned above ("Report on the Exchange between ANTT and ERA - Railway Safety, 2018").

"These national investigation bodies conduct an independent and in-depth investigation into major accidents, and also have the power to investigate incidents, with the aim of preventing recurrence and improving rail safety at national and European level.

National investigation bodies play an essential role in the process of improving safety. The aim of their investigation is not to establish fault or responsibility, but to investigate the causes of the accident and issue recommendations. These recommendations are addressed to the National Safety Authority.

Since there is no concern with establishing guilt or responsibility, there are no external pressures or interests that could induce the direction of the investigations or influence them."

[1] GECOF - Gerência de Controle e Fiscalização de Infraestrutura e Serviços; SUFER - Superintendência de Transporte Ferroviário.

Also according to the aforementioned report, in most EU member states, railway companies are divided into infrastructure managers (mostly state-owned) and railway operators, allowing different operators to run their trains on different railway networks.

In order to guarantee the same level of safety in the face of the effort to harmonize and make compatible the different technical rules and national barriers, railway companies are seeking to improve their safety management by adopting a safety system based on risks that can be generated from the operation and not just on rules.

Railway companies have therefore created their own General Safety Systems (SGS), which list the possible risks that could arise from their operations, so that they can establish all the measures they deem necessary to eliminate or mitigate them, since they have the most knowledge about railway operations.

In this scenario, National Safety Authorities end up inspecting the SGS of each railway company instead of inspecting all the railway sections, rolling stock and other elements. If approved, the NIB issues a safety authorization to the infrastructure managers or a safety certificate to the railway operators.

The SGS inspection can include on-site inspections, interviews with employees at all levels, audits and other methods.

With regard to accident data, the UIC Safety Database is an internet application that provides information on accidents and enables the monitoring of railway safety information.

There are no targets for the number of rail accidents.

According to data from the UIC (UIC Safety Report 2019), it is possible to obtain information on rail accidents according to various forms of aggregation. The following graph shows an example of one of these forms (accidents due to internal and external causes).

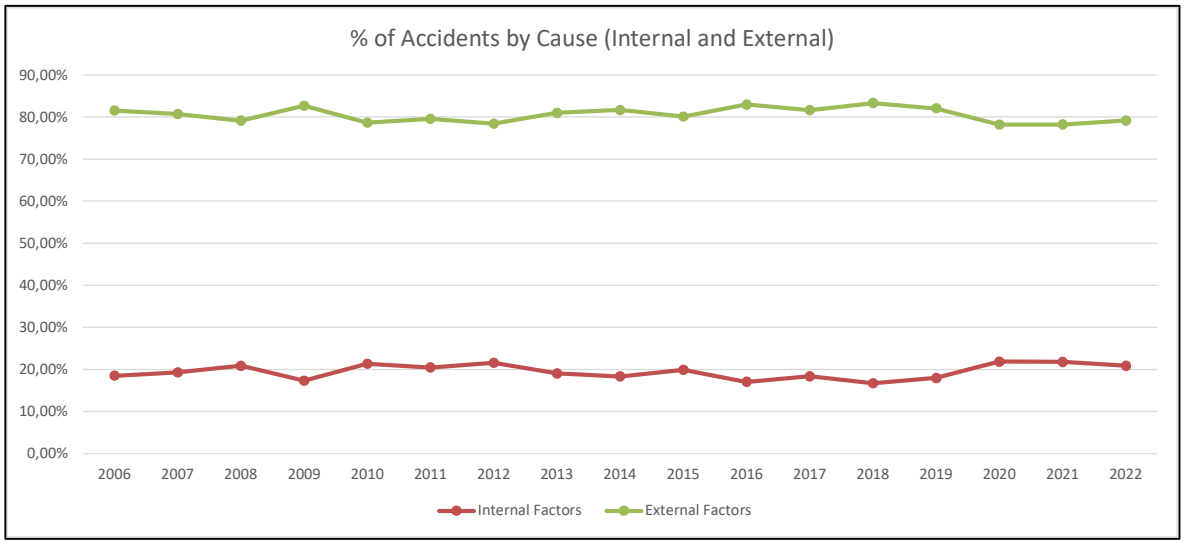

Figure 8: Accidents category by internal and external factors - 2006 to 2018 (Source: UIC Safety Report).

Where:

- Internal causes: infrastructure, rolling stock, human factors and rail users;
- External causes: third parties, climate and environment;
- Accidents in which the cause is not identified are not considered.

Another source, ERAIL (European Railway Accident Information Links) is a platform that contains safety indicators, accident investigation reports and recommendations issued

by accident investigation bodies in Europe. Data can be obtained by member country, type and classification of accidents.

4. Guidelines for Proposed Railway Safety Regulations

Based on the review of the national and international contexts on the investigation of railway accidents and the definition of targets, the points considered important are summarized below:

- Brazil:
  - The issue of "safety targets" is governed by ANTT Resolution No. 5,831/2018, which in turn uses data outputs from ANTT Resolution No. 5,902/2020. Reading the Resolutions together, it can be seen that, despite establishing a classification of rail accidents in terms of their "cause", the current regulations do not provide for accidents to be accounted for separately, by category, for the purposes of measuring compliance with safety targets. The fact is that the lack of segregation in the accounting of rail accidents for the purposes of calculating safety targets has not proved adequate in view of the evolution of the accident rate observed in Brazil in recent years.
  - In Brazil, current regulations set an annual target for the Rail Accident Index (IAF) which, consequently, sets a maximum limit for the number of accidents which, if exceeded, generates a penalty for the concessionaire.

- Internacional:
  - In the cases studied, there is no definition of targets for the number of accidents, so there are no penalties in relation to the total number of accidents;
  - The main concern is to identify the causes of accidents based on the investigations carried out and with the aim of preventing such accidents from happening again. The main objective is not to establish who is to blame;
  - Accident analysis is segmented by cause, thus contributing to investigations and risk mitigation actions.

First, it is essential to make a clear and precise distinction between accidents of "technical origin" and accidents of "third party origin".

Accidents of "technical origin" and accidents of "third-party origin", as already pointed out, have quite different natures and characteristics, and it is inappropriate for any kind of public policy to diagnose them and adopt measures to deal with them in a uniform and indistinct manner.

As a first guideline, it is important to define the aspects that must be present in the proposal to be developed:

i. Definition of concepts and groups of railway accidents according to cause (technical and third party);
ii. Definition of the metrics for quantifying accidents according to the established groups;
iii. Definition of guidelines for controlling the level of railway safety in order to measure compliance with safety targets and create incentive mechanisms according to the groups established.

4.1 Classification of accidents by cause

According to the SAFF/ANTT system, accident data is categorized according to cause:

- FH = Falha Humana (Human factor);
- MR = Material Rodante (Rolling Stock);
- ST = Sinalização, Telecomunicação e Eletrotécnica (Signaling, Telecommunications and Electrotechnics);
- VP = Via Permanente (Tracks);
- OC = Outras Causas (Other Causes);
- IT = Interferência de Terceiros (Trespassing);
- IN = Infraestrutura (Infrastrutucre);
- AV = Atos de Vandalismo (Vandalism);
- FM = Força Maior (Force Majure);
- CF = Caso Fortuito (Act of God).

Based on the existing categories, it is possible to propose the classification of rail accidents into "Accidents of Internal Origin" (or of Technical Origin) and "Accidents of Third Party Origin" (or of External Origin) according to the cause of the accident and the rail operator's direct ability to control it:

- **Accidents of Internal Origin:** all accidents of technical origin that can be considered to be within the direct control of the concessionaire: FH, MR, ST, VP and IN;
- **Accidents of External Origin:** all accidents caused by third party interference and which can be considered to be outside the direct control of the concessionaire: IT, AV, FM, CF and OC;
    - **Other causes (OC):** although the cause of the accident is not clear, it is understood that they are not of technical origin and have been considered as accidents "of external origin".

Considering the suggested reclassification, the following graph shows the behavior of the total number of accidents over the period from 2006 to 2022 by group according to the cause of the accident. It can be seen that accidents categorized by SAFF as "OC" had their classification practically replaced by "Third Party Origin" from 2010 onwards, reinforcing that there is no harm in classifying this type of accident as "External Origin".

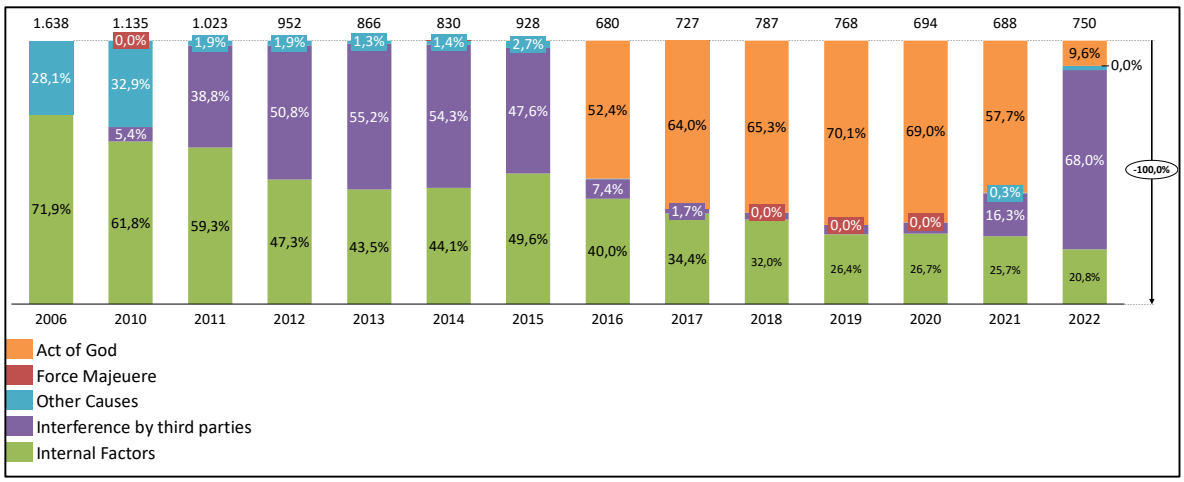

Figure 9: Total accident numbers by cause from 2006 to 2022(Source: SAFF/ANTT).

While accidents of a technical origin (Internal Origin) have fallen over the years, accidents caused by third-party interference have increased slightly or almost remained

stable, even with all the investments already made by the concessionaires to mitigate this type of occurrence, as already mentioned.

In 2022, approximately 80% of accidents were caused by factors outside the direct control of the concessionaire (third parties, act of God and force majeure), most of which were caused by third parties. If we look back to 2006, the ratio was practically the opposite, where only 28% of accidents were caused by external factors.

The behavior of the percentage of accidents by cause over the period from 2006 to 2022 can be seen in the following graph. In 2022, accidents caused by external factors accounted for around 77% of all accidents on Brazilian railroads, with 2011 being the starting year in which there was a reversal in magnitude, with accidents caused by third parties becoming the most representative.

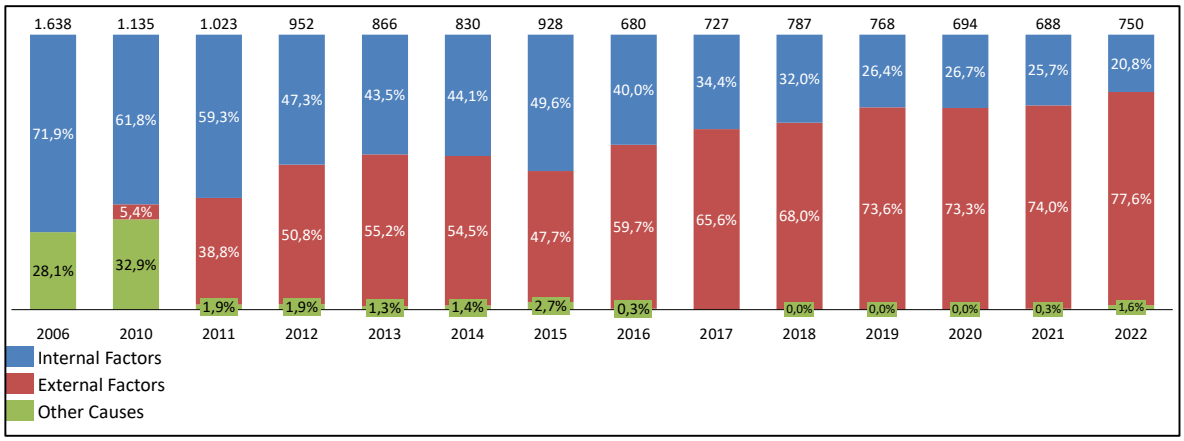

Figure 10: Percentual of accidents by cause between 2006 and 2022 (Source: SAFF/ANTT).

If considered in a segmented way, the Rail Accident Index (IAF) for each group of accidents (Technical/Internal and Third Party/External) shows the behavior seen in the following graph.

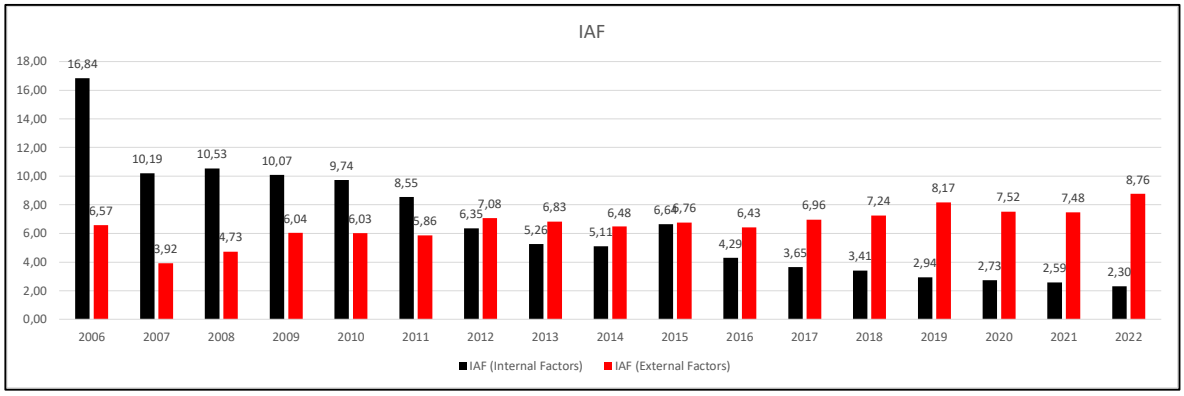

Figure 11: Railway accident Index (IAF) by category (Fonte: SAFF/ANTT).

While the IAF for accidents of technical origin (internal factors) fell by 8 times (86%) between 2006 and 2022, the IAF for accidents involving third-party interference (external factors) increased by around 33%.

Tackling the problem of accidents with a "technical origin" depends on investment and the adoption of specific measures by the concessionaires, and the results of the measures adopted can be seen clearly and concretely. Tackling the problem of accidents with a "third party origin", on the other hand, depends on the adoption of structural measures, with the collaboration of various players, the results of which can only be seen, in a diffuse way, in the medium or long term.

As much as concessionaires strive to develop and implement actions aimed at reducing the number of accidents caused by third-party interference (advertising campaigns, education of the surrounding community, safety, physical barriers, etc.), it can be seen that these types of accidents are caused by other factors that go beyond the concessionaire's ability to control them, be they social, economic or public health factors, and their reduction depends on changes in society's behavior and the development of medium and long-term policies, with the participation of public authorities and organized civil society.

4.2 Metric for Total Accidents by Origin

In the case of the metric for collecting accident data, it is necessary to separate accidents with a "technical origin" and those with a "third-party origin" when accounting for the "accident target" defined for each concessionaire.

In this sense, the metric for measuring the above variables and the way to deal with them should be established separately, considering the characteristics of each type of accident:

- **Accidents of Internal Origin:** sum of all FH, MR, ST, VP and IN accidents:
  - FH = Falha Humana (Human factorr);
  - MR = Material Rodante (Rolling Stock);
  - ST = Sinalização, Telecomunicação e Eletrotécnica (Signaling, Telecommunications and Electrotechnics);
  - VP = Via Permanente (Tracks);
  - IN = Infraestrutura (Infrastructure).
- **Third Party Accidents:** sum of all IT, AV, FM, CF and OC accidents:
  - IT = Interferência de Terceiros (Trespassing);
  - AV = Atos de Vandalismo (Vandalism);
  - FM = Força Maior (Force Majure);
  - CF = Caso Fortuito (Act of God);
  - OC = Outras Causas (Others Causes).

Even with segmentation, it is still possible to calculate the IAF for each type of accident, according to the metric already known below.

$$IAF = \frac{Number\ of\ Internal\ Origin\ Accidents}{Million\ Train\ x\ km}$$

In the case of Accidents of External Origin, the record of the total number of accidents would be kept and segmented by type (IT, AV, FM, CF and OC), allowing even greater detail for the purpose of controlling mitigating actions (e.g. grade crossing, suicide, encroachment on the right of way, etc.), identifying the location of the accident to assess recurrence and define the area of action for the application of mitigating actions, if justified. However, it is understood that, for these cases, the metric of the total number of accidents is more effective for defining mitigating actions.

4.3 Serious Accident Rate (Índice de Acidentes Graves - IAG)

The new addenda for the renewal of the concession contracts specify in their Book of Obligations the indicators to be considered for assessing the provision of the rail transport service, one of which is the Serious Rail Accident Index (IAFG).

The metric for calculating the IAFG is the same as that adopted for calculating the IAF, considering only accidents classified as serious, in accordance with ANTT Resolution No. 5,902/2020. The periodicity for calculating the IAFG is also annual, just like the IAF.

Once again, the classification of an accident as serious is not related to the cause of the accident (technical or third party origin). Regardless of the cause, the accident can be serious or not.

Segmenting the IAFG by the cause of the accident, or origin, is also necessary, since it is difficult for the concessionaire to directly control accidents caused by third-party interference,

As an example, we would have the case of suicide, still considered a rail accident, but caused by a human action by a third party in which even if the concessionaire takes all possible actions to prevent such an act, it is beyond its reach to prevent the attempt and, unfortunately, the suicide from occurring (cases are identified where even with physical barriers, security, among other measures, the act happens). Other examples include death or hospitalization as a result of a collision caused by non-compliance with signs at grade crossings, being run over when a passer-by invades the roadway, etc.

It is therefore necessary to revise the IAFG's safety target regulations in order to segregate accidents in terms of third party and technical causes and to modify the various consequences in the first case, assigning proactive measures to provide for risk-mitigating investments and educational campaigns instead of sanctioning measures.

4.4 Security Level Control Guidelines

Firstly, an instrument needs to be developed for monitoring and evaluating the rates of accidents of external origin (third parties), based on parameters such as the location of the event, seasonality, reaction time, facilitating and limiting factors, among countless others that reflect the non-immediate and plural nature of public policies aimed at reducing the occurrence of this type of event, replacing the pure and simple setting of annual accident targets.

Likewise, it is necessary to develop a reaction mechanism in the event that the "third party origin" accident rate deviates from the established parameters, in particular the preparation, in each case, of an "action plan" that involves the participation of all the actors involved (public authorities, concessionaires, organized civil society, etc.) and defines the short, medium and long-term solution to the problem.

Another guideline to be addressed is the maintenance of quantitative targets, as currently established, only for Accidents of Internal Origin, preserving penalties in the event of non-compliance with these targets.

In the case of Accidents of External Origin, due to their characteristics and the difficult power of direct and unique control on the part of the railway operator, it is understood that the most efficient regulatory treatment would be to consider proactive measures to forecast risk mitigating investments and educational campaigns instead of sanctioning measures, with a view to achieving practical results of further reducing the rates.

The following guidelines stand out:

- The Regulatory Agency and the concessionaires would establish annually, by mutual agreement, the maximum parameters for Accidents of External Origin, as well as the instruments for monitoring them;
- These maximum parameters could be set every 5 years and determined according to the history of the last 5 or 10 years. The maximum parameter could be either the number of accidents or an index to be defined (e.g. number of accidents/million train x km as already practiced) for this type of accident;
- Accidents caused by third-party interference must be reported according to a model to be defined jointly by the concessionaires and the Regulatory Agency;

- The concessionaires must draw up an Action Plan containing the short, medium and long-term measures needed to bring the number of accidents back to the agreed parameters.
- The Action Plan must contain all the actions planned and underway with the aim of mitigating accidents involving third-party interference. This plan must be submitted in the year prior to the year of observation and must be specific to each rail network, containing at least a detailed description of the action, its scope, the estimated budget and the products generated;
- The Action Plan must also present the results achieved with actions already carried out or in progress, where appropriate. The concessionaire must submit information to prove that the actions defined in the Action Plan have been or are being carried out;
- For each Accident of External Origin, the concessionaire must present in the expert report the actions of the Action Plan that would be linked to the mitigation of that type of accident, as well as the lessons learned containing the actions that will be taken so that the same type of accident does not become frequent;
- The Regulatory Agency's analysis would be based on the history of accidents that have already occurred for a given cause. Based on this history, it is possible to identify statistical patterns as well as aspects that contribute to the incidence of this type of accident, thus contributing to the monitoring, control and adjustment of the mitigating actions developed by the concessionaire;
- An effective consequence should be established for cases in which, even after the implementation of the "action plan", the External Accident rates have not reached the parameters considered acceptable by the Regulatory Agency and society in general, including the actual revision of the plan, the carrying out of new investments or the application of specific penalties to the concessionaires in the event of non-compliance with the measures agreed in the plan;
- Significant changes in the standards identified would give rise to an inspection by the Regulatory Agency with the possibility of penalties in the following cases:
    - A warning from the Regulatory Agency as soon as the number of accidents shows an upward trend or is outside known standards;
    - A warning from the Regulatory Agency when the agency considers that the actions defined in the Action Plan are not having the desired effect and that the concessionaire should therefore submit a new Action Plan;
    - A fine from the Regulatory Agency when it is found that the concessionaire has not adopted the measures agreed in the Action Plan or has failed to implement the emergency measures determined by ANTT.
- The aim of the Action Plan will always be to ensure that the number of Accidents of External Origin, or their rate, decreases each year or over a pre-established period, since some mitigating measures can have their effects achieved over a longer period than one (1) year (educational actions, for example).

5. Cost Benefit Analysis

5.1 Current Context

As previously mentioned, under the existing regulations (Resolutions 5.902/2020 and 5.831/2018), all rail accidents are considered in the same way, regardless of the cause,

when verifying that the safety targets of the respective contracts have been met. Once the target is not met, the concessionaire is penalized with a fine.

The communication and investigation of the accident must be carried out immediately after the fact by the concessionaire who, in accordance with the rules established by Res. no. 5.902/2020, chapter III, must communicate the information about the rail accident to the Regulatory Agency:

- Identification of those involved in the accident (total number and number of injuries and deaths) and the agents of the concessionaire holding the concession for the rail network where the accident occurred;
- Data on the accident (date, time and exact location of the event);
- Identification of the rail vehicles involved (prefix, type and quantity);
- Type of transportation being carried out (passenger or freight) and type of goods being transported;
- Classification of the accident by cause, nature and severity;
- Identification of harmful consequences for the environment (leakage, loss of cargo and/or degradation of environmental quality or pollution);
- Color photographic report in electronic or digital format.

Once a train accident has occurred, the concessionaire must report it to the Regulatory Agency:

- In the event of a serious accident, within 4 hours via e-mail and within 24 hours via a system record;
- Other accidents, within 48 hours via a system record.

This communication by e-mail must include:

- Identification of those involved in the accident (total number and number of injuries and deaths) and the agents of the concessionaire holding the concession for the rail network where the accident occurred;
- Data on the accident (date, time and exact location of the event);
- Type of transportation being carried out (passenger or cargo) and type of goods being transported;
- Classification of the accident by cause, nature and severity;
- Identification of degradation of environmental quality or pollution;
- Color photographic report in electronic or digital format.

The investigation of the accident, conducted by the concessionaire, must be based on an expert's report (issued by a professional qualified by CREA and the respective ART) in the case of serious accidents and an investigative procedure (report signed by a representative of the concessionaire) in the case of other accidents.

Also in the case of serious accidents, the report must be submitted to the Regulatory Agency within 30 days of the accident occurring:

- Photographic archive of the accident site;
- Information from the licensing and signaling system generated by the CCO (transcription of on-board computer events, data and voice messages and record of signaling in the field at the time of the accident);
- Interviews with the crew and other witnesses;
- Copy of the police report;
- Identification of injuries or fatalities;

- Assessment of the rules and legislation in force in the case of accidents at grade crossings;
- Calculation of the cost of the accident;
- Proof that the competent authorities were immediately informed in the event of degradation of environmental quality or pollution;
- A set of recommendations for correcting and mitigating the consequences of the accident, as well as for preventing similar accidents.

It is important to note that, in addition to accidents, interruptions in the availability of railroad track to traffic, according to the time of unavailability, must also be communicated to the regulator by e-mail, indicating the location, the reason and the measures adopted or planned to re-establish availability.

Based on what is defined by the resolution in force, reporting rail accidents incurs a regulatory cost for rail freight concessionaires, and it is difficult, and even impossible in some cases, to meet all the requirements and within the established timeframe:

a) Investigating serious accidents by means of an expert report with ART implies more costs for the concessionaire, whereas the investigation report, signed by a representative of the concessionaire, would be sufficient for the Regulatory Agency's inspection and control process.
b) Difficulty in using ART to investigate accidents caused by third parties in which the process of investigating and defining the cause involves analyzing aspects that go beyond the technical capacity of a CREA-licensed engineer. Examples of such cases are accidents caused by suicide, vandalism, among others, and which involve social, psychological and public health aspects, requiring the involvement of different public and private agents.
c) In view of the deadline set, it is difficult, and sometimes unfeasible, to compile the extensive list of information that must be provided when the concessionaire's initial concern and efforts are focused exclusively on protecting life and reducing damage.
d) Depending on the size of the train, the accident could be noticed hours after it actually happened.
e) In many cases, information on injuries or deaths (IML reports) is forbidden to third parties, in this case the concessionaire, and only has to be authorized by the victim's family or guardian. In this case, the concessionaire would have no way of identifying deaths within 30 days of the accident or injuries for more than 24 hours.
f) Since all types of rail accidents are taken into account when calculating the IAF and, consequently, when measuring compliance with the safety targets in the concession contracts, attention should be paid to the fact that accidents caused by the direct fault of the rail operator and those caused by third parties are quite different in nature and characteristics, and it is inappropriate for any type of public policy to diagnose them and adopt measures to deal with them in a uniform and indistinct manner.

As a comparison, we can look at how the FRA reports and investigates accidents. According to the rules established by the FRA, only accidents that meet the criteria should be reported immediately:

(1) Certain deaths or injuries. Each railroad must report immediately, as prescribed in paragraphs (b) through (d) of this section, whenever it learns of the occurrence of an accident/incident arising from the operation of the railroad, or an event or exposure that may have arisen from the operation of the railroad, that results in the:

(i) Death of a rail passenger or a railroad employee;

(ii) Death of an employee of a contractor to a railroad performing work for the railroad on property owned, leased, or maintained by the contracting railroad; or

(iii) Death or injury of five or more persons.

(2) Certain train accidents or train incidents. Each railroad must report immediately, as prescribed in paragraphs (b) through (d) of this section, whenever it learns of the occurrence of any of the following events that arose from the operation of the railroad:

(i) A train accident that results in serious injury to two or more train crewmembers or passengers requiring their admission to a hospital;

(ii) A train accident resulting in evacuation of a passenger train;

(iii) A fatality at a highway-rail grade crossing as a result of a train accident or train incident;

(iv) A train accident resulting in damage (based on a preliminary gross estimate) of $150,000, to railroad and no railroad property; or

(v) A train accident resulting in damage of $25,000 or more to a passenger train, including railroad and no railroad property.

(3) Train accidents on or fouling passenger service main lines. The dispatching railroad must report immediately, as prescribed in paragraphs (b) through (d) of this section, whenever it learns of the occurrence of any train accident reportable as a rail equipment accident/incident under §§225.11 and 225.19(c):

(i) That involves a collision or derailment on a main line that is used for scheduled passenger service; or

(ii) That fouls a main line used for scheduled passenger service.

The FRA may investigate these accidents, to determine the root cause and any contributing factors to the accident, in order to define action plans to prevent or mitigate the risks found in all related entities or with conditions similar to those found. These actions could include, but are not limited to, corrective maintenance, changes to operating rules, changes to maintenance and/or inspection procedures, new safety rules and new federal regulations.

There is no set deadline for the completion of investigations, but the aim is to complete the investigation within 270 days. Once the investigation is complete, a final written report is generated describing the accident and the actions taken.

Other accidents that do not fall under the above definition must be reported through monthly reports sent to the FRA by the railroads. Reports shall be completed as required by the current "FRA Guide for Preparing Accidents/Incidents Reports.". The report must be submitted within 30 days of the end of the month in which the accident occurred.

5.2 New Proposal

It is understood that the proposal suggested in this paper does not have a significant impact on the costs already incurred by the concessionaire in reporting and investigating rail accidents, or by the Regulatory Agency in controlling them.

On the contrary, there is a reduction in regulatory costs without losing the benefits already gained from the process of investigating and mitigating rail accidents, since:

- There would be no requirement for an expert report with ART, as the investigation report drawn up and signed by the concessionaire's

representative would already guarantee responsibility for investigating the accident, maintaining all the information currently required.

- With more experience of railway operations and their impacts, the concessionaire would propose mitigating actions in the case of accidents caused by third parties, bringing more transparency to the regulator about what is being planned and executed, as well as allowing for greater monitoring and action by other public bodies, which would certainly help in tackling certain causes of accidents.
- Continuous monitoring and review by the regulator of mitigating actions and assessment of their impact.
- Greater transparency and improvement of the database on accidents caused by the actions of third parties, since the aim would no longer be to identify a culprit, but rather to find ways to prevent a new occurrence or mitigate the possible causes of such human behavior.

6. Risk Analysis

It is believed that, on the part of the regulator, there is a presumption of risk, as it may seem that, once an accident caused by a third party is not taken into account when measuring compliance with the safety target in the concession contracts, the concessionaire would not feel motivated to investigate or invest in mitigating actions.

This presumption of risk cannot be sustained for at least two reasons:

- The proposal that the concessionaire draw up and submit an Action Plan for these cases, and its constant evaluation by the regulator, guarantees continuity in the investigation process and in the provision of information about accidents that have occurred. In addition, Law 14273/2021 itself establishes this continuity on the part of the railway operator.
- The railway operator does not benefit in any way from the occurrence of a train accident, as it has an impact on the operation and, consequently, on the profits to be made from the service. In this way, investigating and seeking actions to prevent a new occurrence are processes inherent to the railway operation, given the high cost of this stoppage.

Another risk, presumed by the regulator, would be that the concessionaires could claim that there was a need to review the economic and financial balance of the contracts, given that the actions set out in the Action Plan had not been provided for since the start of the concession.

It is believed that the second reason presented above would also be valid for eliminating this risk, since it is important to mitigate accidents and these are already actions carried out by the concessionaires today, without any provision in the contract. In any case, it is believed that this would be an easy point to negotiate with the operators, since these types of accidents would no longer be considered for the purposes of the safety targets in the contracts.

7. Project Plan / Implementation Plan

In order to implement this proposal, the existing resolutions on rail accidents (Resolutions 5.902/2020, 5.831/2018 and Ordinance No. 144/2020) would have to be reviewed, also taking into account what is established by the new legal framework for railroads (Law No. 14273/2021).

Another alternative would be to establish a trial period for the new method in order to identify possible adjustments and needs for improvement in the regulation currently in force. This experimental regulatory environment is called a "Regulatory Sandbox" and it is

an environment in which the regulatory body allows a company to operate with different rules from other companies for a certain period in order to test some innovation.

In any case, as stated above, it is understood that some aspects would be part of this innovation process:

- The Regulatory Agency and the concessionaires would establish annually, by mutual agreement, the maximum parameters for accidents caused by third parties, as well as the instruments for monitoring them;
- These maximum parameters could be set every 5 years and determined according to the history of the last 5 or 10 years;
- Accidents caused by third party interference must be reported according to a model to be defined jointly by the concessionaires and the Regulatory Agency;
- The concessionaires must draw up an Action Plan containing the short, medium and long-term measures needed to bring the number of accidents back to the agreed parameters.
- The Action Plan must contain all the actions planned and being carried out with the aim of mitigating accidents involving third party interference;

8. Financial Plan

As this is a conceptual proposal and a revision of the procedure for dealing with accidents caused by third parties, it has not yet been possible to carry out the financial analysis at this current conceptual proposal stage.

It is suggested that the Financial Plan be part of the ongoing development of this work.

9. Final Considerations

As we have already seen, international literature indicates that reducing the number of accidents caused by "third parties" is much more difficult and complex than reducing the number of accidents caused by "technical factors", as it depends on changes in society's behavior and the development of medium and long-term policies, with the participation of public authorities and organized civil society.

Tackling the problem of accidents with a "technical origin" depends on investments and the adoption of specific measures by the concessionaires, and the results of the measures adopted can be seen clearly and concretely. Tackling the problem of accidents with a "third party origin", on the other hand, depends on the adoption of structural measures, with the collaboration of various players, the results of which can only be seen, in a diffuse way, in the medium or long term.

Among the actors mentioned are the municipal and state administrations, the public prosecutor's office, social organizations and others. The joint work of these actors can help mitigate accidents caused by third parties related to, for example, suicides, vandalism, disrespect for signs at road-rail junctions, trespassing, etc.

Specifically in the case of accidents caused by "third parties", it is important to mention the numerous actions promoted by concessionaires aimed at reducing accidents, including:

- Educational campaigns and programs in schools, the community and the media;
- Improved signage;
- Partnership with public authorities to implement actions to reduce the number of road-rail crossings;
- Social programs in communities along the railway;

- Mapping risk locations;
- Increasing the number of corporate security personnel;
- Installation of monitoring cameras along the railroad;
- Fencing of urban and rural areas at critical points;
- Escorts to accompany trains;
- Revitalization of grade crossings; (k) construction of a safe path, among others.

In addition to the concern about social, environmental and psychological impacts, a train accident is a naturally undesirable occurrence for the railway operator due to the impacts it has on transport production. Therefore, the railway operator will always take action to ensure that the number of accidents is as low as possible, regardless of the cause.

The point is that sanctioning the concessionaire with fines for failure to meet the safety target, when it considers accidents whose mitigation would be beyond the concessionaire's direct ability to eliminate them, would be unfair and inefficient in terms of the results desired by the regulator since this type of accident is caused by the interference of a third party in the operation of rail transport, even with all the measures adopted to prevent it.

We are not discussing the elimination of safety targets by Brazilian regulation, given the need for a more in-depth analysis of both the current regulation and the current structure that would be needed to investigate rail accidents, but only that the target consider what can actually be attributed to the concessionaire's management. In this way, there is room for a broader discussion with the aforementioned players and the joint construction of effective, non-isolated actions to reduce accidents involving third parties.

In this way, segregation according to the cause of the rail accident for the purposes of measuring compliance with safety targets brings greater efficiency to the regulatory treatment to be given to accidents caused by third-party interference.

The guidelines presented also signal the development of a proposal that guarantees the investments already made by concessionaires to mitigate this type of accident, their expansion and even their improvement.

The next step will be to draft regulations based on the established guidelines and the maximum possible standardization of the elements to be considered, taking into account the reality of all rail freight operators.

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