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A FRAMEWORK FOR CATEGORIZING RISKS IN HIGH SPEED TRAIN (HST) PROJECTS: THE EXAMPLE OF THE FIRST HST IN BRAZIL

Summary. High Speed Train projects are exposed to risks of different natures, such as: low participation of private companies in the new railways construction, lack of skilled labor, high technology not available in the internal market, high costs with land acquisition, among others. Such risks if not managed properly can become real problems and compromise the achievement of the project objectives. The risk identification is the process of collection and description of events that can have negative effects on the project. This process should consider the project uncertainty elements in order to generate specific results. In the case of HST projects, examples of uncertainty elements are: politics, economy, environment, human resources and technology. Therefore, this study aims to present a framework for categorizing risks to be used in HST projects. Also, for each category proposed some risk examples are suggested. An overview of the first Brazil HST project is showed and the risk framework is proposed. A discussion on the risks in the first Brazil HST project are presented followed by final conclusions.

UMA ESTRUTURA PARA CATEGORIZAÇÃO DE RISCOS EM PROJETOS DE TRENS DE ALTA VELOCIDADE (TAV): O EXEMPLO DO PRIMEIRO TAV DO BRASIL

Resumo. Projetos de trens de Alta Velocidade estão expostos a riscos de diversas naturezas como: baixa participação de empresas privadas na construção de novas ferrovias, falta de mão de obra especializada, tecnologia de ponta não disponível no mercado interno, altos custos com aquisição de terrenos, alto impacto ambiental, entre outros. Tais riscos senão forem gerenciados corretamente podem se tornar problemas e comprometer os objetivos do projeto. A identificação de riscos é o processo de coleta e descrição de eventos que podem ter efeitos negativos sobre o projeto. Este processo deve considerar os elementos de incerteza do projeto, a fim de gerar resultados específicos. No caso de projetos de TAV, são exemplos de elementos de incerteza: política, economia, meio ambiente, recursos humanos e tecnologia. Portanto, este estudo tem como objetivo apresentar uma estrutura para classificar os riscos a ser usada em projetos de TAV. Para cada categoria de risco, exemplos de riscos são apresentados. Uma visão geral do primeiro projeto de TAV do Brasil e seus principais riscos são mostrados. Finalmente, tem-se uma discussão sobre os principais resultados do artigo e as conclusões finais.

1. INTRODUCTION

High speed is a highly beneficial transport system for society that is becoming more and more popular world-wide. At the present time there are High Speed established systems of varying ages in different European and Asian countries and at the same time, there are other nations looking into building new routes, including Brazil [1].

The first High Speed Train (HST) project in Brazil will have 511 km of route between Rio de Janeiro, São Paulo and Campinas, with seven stops on the way. The Brazilian HST project continued to be subject of technical studies by the Company of Planning and Logistics (EPL), which it is close to be completed to, after that, conduct the auction to select the operator and the HST technology.

The design, construction and operation of a new HST system is a complex task with many influences, stakeholders, requirements, challenges and objectives which must all be taken into account. Within this context, HST projects are exposed to risks of different natures as low participation of private companies in the new railways construction, lack of skilled labor, high technology not available in the internal market, high costs with land acquisition, high environmental impact, among others. Risk management is a formal and systematic management process that seeks to identify, analyze, treat, monitor and control project risks, throughout the life cycle of the same.

The risk identification process, the focus of this study, consists of identifying and describing the potential negative events of the project and their consequences for the project. The risk identification process should consider the project uncertainty elements in order to generate results targeted to the project context. During our literature review, no study dedicated to specification of these uncertainty elements and the risks was found. Thus, the present article propose a framework for categorizing risks in HST projects. Such framework will enable to identify specific risks to a HST project and serve as input for the following risk management processes. Also, for each category some risk examples are showed. The risk framework proposed, is applied to the case of the first HST project in Brazil.

With this article it is hoped that the stakeholders of an HST project will increase the quantity and quality of risks which are identified, as well as develop a pro-active culture within the project.

2. RISK MANAGEMENT

As projects are about doing something new, they are about change. Change introduces uncertainty and uncertainty is risk [2].

Project risk is an uncertain event or condition that, if it occurs, will cause a positive or negative effect on one or more project objectives such as scope, schedule, cost and quality (PMI, 2013). Most authors dealing with risk management considers the risk definition in terms of their probability and impact [3].

Known risks are those that if are identified and analysed, enable the response planning in order to reduce the occurrence probability or the severity of impacts on the project [4].

Risk Management (RM) is about the steps you take in a systematic way that will enable to identify, assess, response and control risk [2]. A good RM procedure will support better decision-making concerning risk, as there will be a better understanding of the risks, how these risks will affect the project and the responses to these risks if they should occur. Project risk management objectives are to increase the probability and impact of positive events and reduce the probability and impact of negative events in the project [2, 4].

Risk management begins with the risk identification and description process [2, 4]. It is recommended to identify and record potential risks arising from interactions related to the activities, process and product of the project organization, the required organization and the stakeholders [5]. The main benefit of this process is the documentation of existing risks and the knowledge and ability that it provides to the project team to anticipate events.

There is a variety of techniques to identify risks as: brainstorming, interviews, comparison by analogy, Delphi technique, SWOT (Strengths, Weaknesses, Opportunities, and Threats), checklist, WBS (Work Breakdown Structure), FMECA (Failure Mode, Effects, and Criticality Analysis), FTA

(Fault Tree Analysis), analysis of the project life cycle, critical path analysis, decomposition and classification of risks into categories according to their sources of origin [2, 4, 6, 7-9].

The risks can be classified by categories to help identify specific risks taking into account the project context [3]. The following risk categories are proposed:

- Input risks: risks arising from the input information to be transformed by the product design activities.
- Domains risks: risks relating to the project team (e.g. technical specialists) and the product clients/customers in terms of knowledge domains required in the product design activities.
- Mechanism risks: risks derived from the methods, tools and other resources to be used in the execution of the activity.
- Output risks: risks arising from the output information or physical objects to be transformed by the product design activities (deliveries).

About the project management, the following risk categories are defined:

- Scope risks: risks related to the product and project scope;
- Time risks: risks associated with product design process and the project schedule;
- Cost risks: risks related to the project costs;
- Quality risks: risks associated with the desired quality of the result.

The risks from product design and project management categories are called, respectively, technical risks and management risks.

To aid in the technical risk identification, a set of investigative questions is proposed, as presented in Fig. 1.

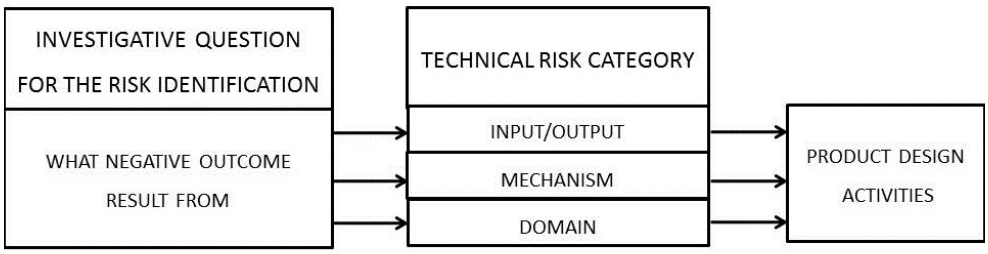

Fig.1. Formularization of investigative questions for the technical risk identification [3]
Il. 1. Formulação de questões de investigação para a identificação de riscos técnicos [3]

These questions seek to stimulate the project team to think about the possible product design risks, considering the inputs, domains, mechanisms and output of this process, that is, the technical risk categories.

Examples of investigative questions are: What negative outcome could result from the activity "Identifying the client/customer needs" in terms of information availability? What negative outcome could result from the activity “Establishing the product functional structure"? What negative outcome could result from the activity “Developing the product layout”?

Often, the project is subject to management risk that if not properly managed can seriously compromise the project progress and results. In this sense, the scope, time, cost and quality risks are identified, based on the project plan previously defined by the product development team [3].

For the identification of the scope, time, cost and quality managerial risks a structure for the investigative questions similar to that of the questions suggested for the technical risks is also proposed. Once again, the objective of these questions is to stimulate the project team to think about the possible risks, in this case, the managerial risks.

To answer these questions, the project team should reflect on the possible risks based on the project plan and having in mind "what" should be investigated on the scope, time, cost and quality of the project, i.e., the categories of managerial risks previously defined [3].

The risks highlighted from the investigative questions and from the risk bases will form the technical and managerial project risk list.

3. A FRAMEWORK FOR CATEGORIZING RISKS IN HIGH SPEED TRAIN (HST) PROJECTS

From the technical risks and management risks categories, specific risks categories for an HST project were defined, as shown in Tab. 1.

Table 1

Equivalence matrix between risk categories

Technical risks Categories.		Management Risks Categories.	
Product design	HST project	Scope	Scope
Input	External	Time	Time
Domain	Stakeholders	Cost	Cost
Mechanism	Project	Quality	Quality
Output	Output		

For each category, examples of possible risks will be presented.

External Category: risks from the macro environment, which should be limited for the proper risk management. In the case of a high-speed rail projects, the external risks subcategories were defined as shown in Tab. 2.

Stakeholder Category: are the risks concerning the project stakeholders and affected by it, as shown in Tab. 3.

Project Category: HST project technical risks are those derived from the implementation of the project phases and activities. The implementation process of the High Speed Railway System is divided in five different phases: emerging phase; feasibility phase; design phase; construction phase [1]. Risks were defined as shown in Tab. 4 for each phase.

Output Category: risks associated to the outputs of each stage of a High Speed Railway System Implementation (Emerging, Feasibility, Design, Construction and Operation phases). Tab. 5 shows output risk examples.

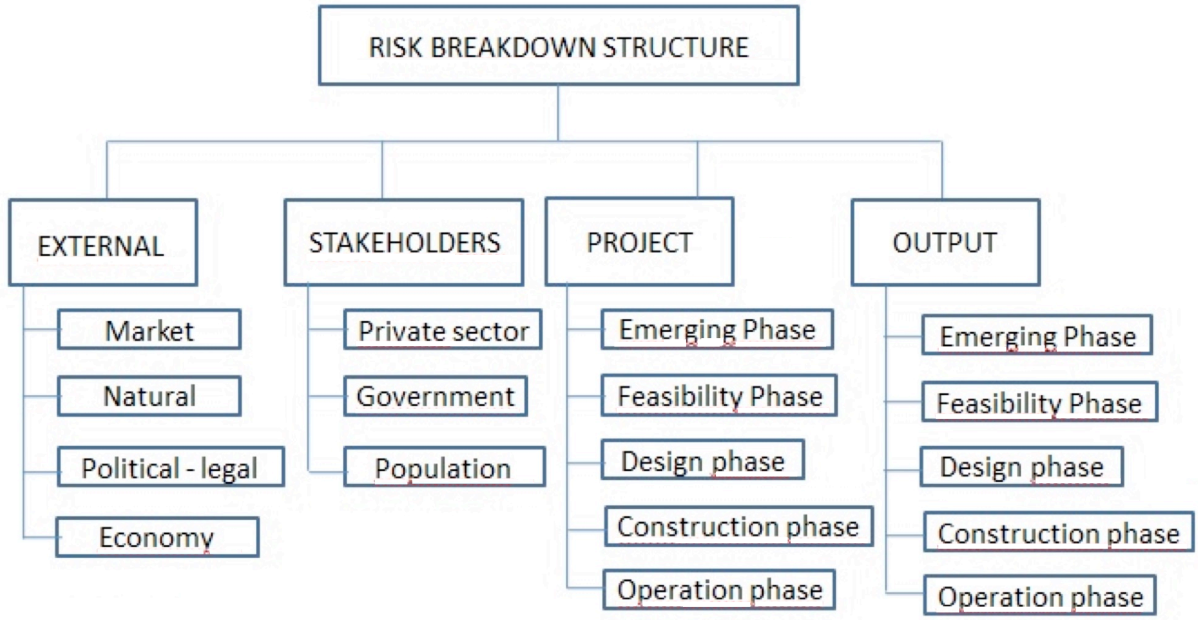

Fig. 2. Technical Risk Breakdown Structure for a high-speed train project
Il. 2. Técnico Estrutura Analítica de Riscos para um projeto de trem de alta velocidade

Table 2

External risk category

External risk category	
Subcategories	Risk examples
Market	Foreign currency debts External indices that reflect inflation Losses due to investments in share
Natural	Risks related to the weather (hurricanes, earthquakes, floods, long periods of rain).
Political-legal	Civil war War with another country Government Change priority Investment lack Changes in legislation - labor, commercial, tax, foreign exchange and intellectual property.
Economy	Crises in partner countries Inflation Tax increases Credit volume reduction Increase in interest rates Blocking funds in banks Exchange rate variations

Table 3

External risk category

Stakeholder Risk Category	
Subcategories	Risk examples
Private Sector (bank, dealers, construction companies, environmental stakeholders, railway Industries)	Little private sector participation in the railway project; Little investment to improve the system operation; Passenger volume below projections; Loss of users due to high prices and/or the low service quality; Unavailability of land
Government (Transport Ministry, Regulators)	Risk of costs and operations absorbed by the State in case of failure of the private operator; Risks of delays and costs beyond the budgeted and obligations from obtaining prior licensing and installation; Risk of power supply interruption to the HST operation by failure which is not the Concessionaire's responsibility
Population (Civil entities and affected owners)	Low price paid for expropriation of buildings; Delay in receiving the expropriation money; Resistance to leave the local; High value of ticket; low quality of service; system poor reliability; Major local opposition at the public hearings

Table 4

Project risk category

Project Category	
Subcategories	Risk examples
Emerging Phase	No financial agreement Stoppage of the process Lack of political support Opposition of environmental lobbies
Feasibility Phase	Imperfect knowledge of the market; Too pessimistic or optimistic traffic forecast; Refusal by the government authority to authorise a project because of problems with the quality of the data and/or studies submitted Difficulties with land acquisition
Design phase	Uncertain knowledge; Lack of input data; Emerging technical equipment unavailable in time; Obsolescence of technical equipment; Change in standards during design lifecycle; Inappropriate technical solutions

Construction phase	Lack of electricity and water; Risks of pollution of the surface water as a result of leaching caused by rainwater from earthworks areas, or pollutant waste from works machinery; Risks of damage to the beds and banks of water courses during work on building bridges over rivers or when diverting the course of rivers and streams; Risks of natural habitats being damaged by worksite waste
Operation phase	Risk of collisions; Increased prices: an increase in prices raises operation and maintenance costs; Inadequacy of environmental measures; Low maintainability; Low reliability; Damage caused to the concession property

Table 5

Output category

Output Category	
Subcategories	Risk examples
Emerging Phase	Not definition of a project owner; Incomplete funding plan for studies during the emergence phase; Wrong decision about go ahead with studies; Clarity lack in the study specifications
Feasibility Phase	Extra land acquisition; Environmental management plan not completed; Financial and socioeconomic indicators of the project unreliable; Superficial risk analysis
Design phase	Clarity lack in the exploitation model; Low confiability in the operational and maintenance costs; Collections of incomplete drawings; Incomplete technical specifications
Construction phase	Incomplete railway construction; Insufficient tests; Incomplete approved technical file; Not authorisation to place the new line in service
Operation phase	Failures in the day to day operation; Failures in the day to day Maintenance; Incomplete evaluation report; Non-application of the recommendations

For an HST project management, some risk examples are:

- Scope risks: Carry out more activities than necessary; frequent changes in the track scheme.
- Time risks: Inappropriate schedule, delays in schedules established between the project parts.
- Cost risks: Inappropriate financial resources estimates; project financial resources extrapolation.
- Quality risks: Quality tests made in haste and without strict safety criteria.

4. HIGH SPEED TRAIN

From the first train, which started operating in 1964 in Japan, the use of high-speed rail systems in the world was expanded considerably. These systems which technically still are improving in terms of safety and operational speed, expanded their network [10].

An example of this evolution is the initial train operational speed of 210 km/h which nowadays achieves 350 km/h. The rolling stock manufacturers are managing the next generation of trains, mostly multiple units with better energy performance and potential speed between 350 and 400 km/h [10].

4.1. Brazil HST – Overview

In Brazil, for some time the feasibility of deploying a high-speed rail line between Rio de Janeiro and São Paulo has been subject of studies.

In 2012, the federal government set up the Planning and Logistics Company (EPL) to structure and implement an integrated planning of logistics in the country. In addition, the EPL will be responsible to plan and promote the development of the high speed rail service in the country.

As the latest studies are 2009, an update on the passenger demand and in the project track has been made. However, before launching a public competition, the EPL is waiting for a government policy decision on the continuation of the project [10].

The route of the Brazil HST project will be between São Paulo and Rio de Janeiro. The HST line fulfils a concept to connect the airports of Guarulhos (São Paulo), Viracopos, Campinas (SP) and Galeão (Rio de Janeiro) to their metropolitan areas.

The metropolitan regions and cities where the establishment the HST stations is planned adds up to nearly 20% of the population. The cities of Campinas, São Paulo and Rio de Janeiro are areas of great importance due to its historical and territorial mobility of people, goods, information, thus it is important for materialization of this movement [11].

The total estimated distance between Campinas and Rio de Janeiro is 511 km; with the distance between São Paulo and Rio de Janeiro about 412 km. The total travel time between the two cities is estimated at approximately 1 hour 33 minutes. It is noteworthy that travel times are approximate and are based on a maximum operating speed of 300 km/h [10].

Fig. 3 shows a diagram where it is showed the population of major urban areas that receive stations. The estimated demand for the year 2014 was 32.6 million people and the forecast demand for the year 2024 it is to achieve 46.1 million people [10].

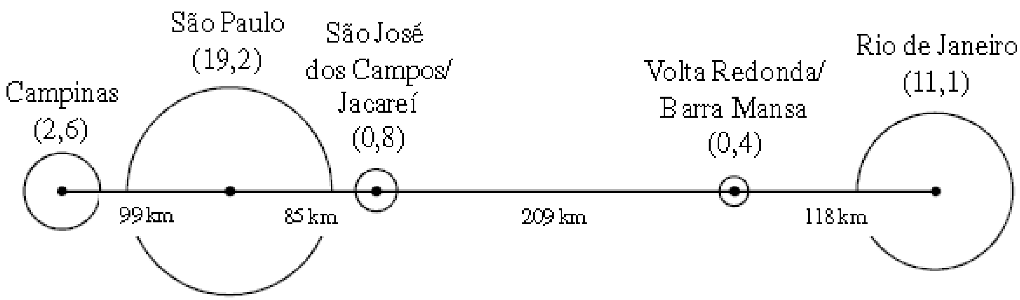

Fig. 3. Population of urban areas that receive stations of the Brazil HST [10]
Il. 3. População de áreas urbanas que recebem estações do Brasil HST [10]

In addition to the socio-economic aspect, the technical studies under the project engineering, is another point to be established in the Brazil HST project based on international standards of high-speed lines.

It is expected in the current feasibility studies, that HST will not share any existing track or operate with existing Brazilian services of railway or metro. The HST route provides for dedicated tracks to the main station in each city, with the route often located in tunnels in densely populated urban areas.

5. RISKS IN THE FIRST BRAZIL HST PROJECT

In the first Brazil HST, according to the Institute of Applied Economic Research [12], some potential investors highlight two risks that could derail the project.

The first one is the initial cost of the construction (emerging phase) which may exceed the government budget. The second risk is related to the low passenger demand (feasibility phase) and hence the expected revenues are lower than projected (operation phases).

Thus, the high investments and implementation risks, in addition to the long-term return that the first HST project in Brazil is subject, has made it unattractive to private sector. Therefore, it is important to involve the federal government in the HST project. The first HST in Brazil can be justified by the fact that the benefits go beyond business profitability. The social and environmental benefits should be the purpose of public investment.

Also, it is important to take into account that the Brazilian project has almost all the features that, according to international literature, make it more expensive. The track scheme will have inclined track to climb the Serra do Mar (leaving from Rio de Janeiro and arriving in São Paulo which has an average altitude of 760 m), it will pass through several tunnels and viaducts, cross high cost land of expropriation, go through areas of high population density (which increases the compensation costs), it will not use existing rail network and it will cause high environmental impact because of the Atlantic Forest.

Tab. 6 presents the most relevant risks in the first HST project in Brazil, taking into account the risk subcategories proposed in this paper.

Table 6

Some risks in the Brazil HST project

Stakeholders category: Private Sector	Project Category: Construction phase
Passenger demand and expected revenues lower than expected	Damage to the beds and banks of water courses during work on building bridges over rivers or when diverting the course of rivers and streams.
Management category: Time	Management category: Cost
Delays in schedules due to the lack of experience and project complexity.	Initial construction costs that may exceed the government estimates.

6. FINAL CONSIDERATIONS

From a managerial perspective, this article is important to facilitate the risk category identification and its risks in the HST projects. It is hoped that the stakeholders will increase the quantity and quality of risks which are identified, as well as develop a pro-active culture within the project.

In future studies, this research model needs to be tested in practice in order to validate the risk categorization model in HST projects and assess its efficiency, as well as to evaluate the risks proposed here.

It can be concluded that the first HST project in Brazil is very important because it establishes the connection between the two largest population centers in Brazil, one of them the world's largest. In addition, nowadays the people mobility between these two metropolitan areas occurs only through road transport, which is slow, and air transportation. The air transportation, although efficient, is under risks of interruptions and delays that can cause major disruptions.

The first HST project in Brazil has a clear nature risk, since these metropolitan areas are separated by the Serra do Mar, which is at an altitude of 900m, with hills and valleys. This fact raises the project cost, mainly in the construction and operation phases. The little experience of Brazil in this type of project is another important risk, as well as foreign companies that do not hold expertise for projects of this magnitude in regions such as Brazil.

Considering the types of risk related to this important project, especially in the academic environment, is a mandatory task. It was one of the drivers for publication of this article, more specifically to share and exchange knowledge about HST projects with experts in the field in order to stimulate a discussion about the High Speed Train in Brazil.

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