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## **RAILWAY INDUSTRY ROADMAP IN THE STATE OF SANTA CATARINA, BRAZIL**

**Summary.** This article aims to identify the main requirements to strengthen the railroad industry in Santa Catarina by using technology roadmapping. The railway industry is composed of carriers, manufacturers, suppliers, operators, logistics, services and education. The survey aimed to provide guidelines for the Federation of the State of Santa Catarina Industry (FIESC) to develop its strategic plan for the next eight years. Based on the survey, the roadmap defined vision, mission, a list of key concepts, drivers and actions for the Federation to support the railway industry development, since this industrial sector is still economically unrepresented when compared to other sectors in Santa Catarina. The survey also pointed out there is a strong expansion program of the railway freight and railway transport for people in Brazil, both in government and private sectors.

## **ROADMAP PARA A INDÚSTRIA FERROVIÁRIO DO ESTADO DE SANTA CATARINA, BRASIL**

**Sumário.** Este artigo objetiva identificar os principais requisitos para fortalecer a indústria ferroviária em Santa Catarina (SC), por meio da aplicação do processo de *technology roadmapping*. A indústria ferroviária é composta por transportadores, fabricantes, fornecedores, operadores de logística, serviços e educação. A pesquisa objetivou fornecer orientações para a Federação das Indústrias de Santa Catarina (FIESC) com a finalidade de desenvolver um plano estratégico para os próximos oito anos. Baseando-se na pesquisa, definiram-se a visão, missão e uma lista de conceitos chaves, drivers e ações para que a FIESC apoiasse o desenvolvimento da indústria ferroviária, uma vez que esta é economicamente pouco representativa em comparação com outras indústrias no estado de SC. A pesquisa apontou que há forte expansão do transporte de cargas e pessoas no Brasil, tanto nos setores governamentais quanto nos setores privados.

### **1. INTRODUCTION**

Nowadays, the railway density in Brazil is very low compared to other countries. The country has 3.5 km of rail infrastructure per 1,000 km<sup>2</sup> area, against 22.9 in the United States, 19.5 in India, 9.0 in China, 5.1 in Russia and 4.7 in Canada [5].

According to the National Land Transportation Agency (ANTT), by the end of 2009, the Brazilian rolling stock of rail equipment accounted a total of 92,890 freight cars and 2,876 locomotives [4]. In 2010, the rail system cargo handling corresponded to 21% of the Brazilian cargo transportation matrix. In 2011, the Brazilian railway system had 30,000 km in length, composed of 11 private threads and 1 public [5].

In 2013, the main products transported by rail were [25]: iron ore and mineral coal (75.71%); agribusiness (14.86%); steel products (3.77%); alcohol derivatives (2.79%); and construction (0.57%). Also according to the same reference, it is expected a growth of 12.5% in the Movement of Carried Cargo between 2014 and 2016, for a total of 550 million useful tons (TU), in comparison to 490 million TU in 2013.

In Santa Catarina, the total railroad network length is 1,393 km [6] and is linked to the Brazilian infrastructure through the ports of Paranagua and Rio Grande [10]. According to the Federation of the State of Santa Catarina Industry (FIESC) data, the state railway is conceded to Tereza Cristina Railroad (FTC – Ferrovia Tereza Cristina) and to the Latin America Logistics Company (ALL). As inferred from the data, the state railroad is important due to the diversity of transported products. In order to strengthen the railroad industry in Santa Catarina (SC), FIESC [8] commissioned a study to reveal the opportunities to establish a more robust railway industry in the State, but more importantly, to establish a long term planning until the year 2022. The FIESC main aim with this initiative was to promote regional economic development throughout the State by supporting the regional railroad industry.

The Brazilian government is putting much effort in overcoming its infrastructure problems and the development of the railroad industry may contribute with this effort, backed up with Bi USD in investment. Thus, the aim of this paper is to identify the main requirements to strengthen the railroad industry in Santa Catarina by using technology roadmapping.

## **2. TECHNOLOGY ROADMAP**

The technological change and the impact of globalization in organizations increase competitiveness of industries and countries and bring technology and innovation as the focus in decision making [2]. Market and technology are constantly changing, accompanied by the pressure for increasing costs, demand and reduction in product life cycle. In this context, businesses, government and other entities should focus on emerging markets and the use of strategic technology planning [1].

The integration of technology with business strategy is an important aspect of planning, since such integration brings value and competitive advantage [21]. Technology management requires processes and systems that, in practice, are able to identify whether the existing and potential technological resources within a sector or organization are in accordance with their present and future needs.

Technology Roadmapping (TRM) is defined as [11]: roadmaps communicate visions, attract resources from business and government, stimulate investigations, and monitor progress. They become the inventory of possibilities for a particular field, thus stimulating earlier, more targeted investigations. They facilitate more interdisciplinary networking and teamed pursuit. Even “white spaces” can conjure promising investigations. In engineering, the roadmapping process has so positively influenced public and industry officials that their questioning of support the technologies have to offer are very important.

A "roadmap" in its generic term corresponds to a layout of paths or routes that can exist in a certain geographical area and acts as a travel plan director [18], as well as a map that shows the way considering the starting and ending points and its critical aspects [7].

The roadmapping process allows the integration of business and technology [14]. TRM is a technical support to the planning and management of technology, exploration and communication of the relationship between technological resources, organizational goals and changing environment [21]. TRM is a higher-level strategy for the development of alternatives technologies, providing a way to identify, measure and select these alternatives, in order to satisfy a need [12, 18].

A study focused on 40 roadmaps in 16 different areas, identified different types of roadmaps [21]. Fig. 1 presents the purposes and shapes identified. Regarding the TRM construction, the following phases were proposed [12, 24]:

- Phase 1 - preliminary activities: to find the essential conditions; in order to define leaders, supporters, sponsors, scope and boundaries for the TRM;
- Phase 2 - TRM development : identification of "product" focus; critical system requirements and targets; specification of key technology areas; the drivers and their targets; identification of alternative technologies related to time; recommendation of technological alternatives to be followed; creation of the TRM report;
- Phase 3 - Follow-up activities: TRM criticism analysis and validation; development plan and implementation; review and update.

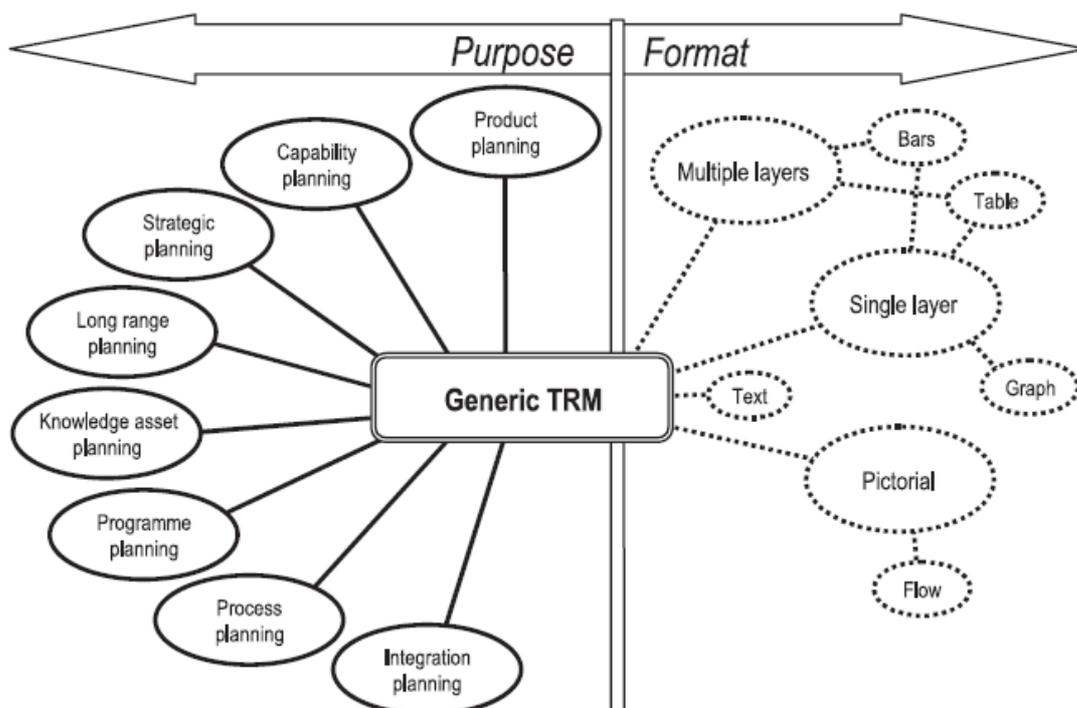


Fig. 1. Characterization of roadmaps by purpose and format. Source: [21] (p. 11)

Il. 1. Caracterização de roteiros por finalidade eo formato. Fonte: [21] (p. 11)

The main TRM benefit is to improve decision-making and investments planning [19]. According to [14], these benefits are:

- Establishment of a strategy that relates product and technology;
- Definition of an interrelated approach to a plan and long-term vision for technology and product;
- Stimulus to knowledge and communication improvement;
- Best competitive advantage obtained through the timing of the breeding market and money;
- Best quality in the product process specification.

### 3. METHOD

The team that conducted this research consisted of senior professors, PhD and Masters students from the Entrepreneurship Lab (LEMP), from the Industrial and Systems Engineering Department, and the Integrated Product Development Nucleus (NeDIP), from the Mechanical Engineering Department, research labs from Federal University of Santa Catarina (UFSC).

Based on the research objective, the team opted to follow the S-Plan Method for Technology roadmapping proposed by [22], which is originally composed of three phases: (i) planning, (ii) roadmapping workshops and (iii) review. In addition, it was opted to follow the recommendations to use a customized workshop approach [21]. The study was mainly exploratory, which slightly differs from the original S-Plan Method.

The major steps involved in the work were:

1. For the roadmap development, it considered the rail sector described in CNAE-30 (Classificação Nacional de Atividades Econômicas / National Classification of Economic Activities in Brazil), mentioned above [17];
2. Seven drivers were defined, as recommended by different TRM methodologies [3, 15, 16, 23]:
  - Technology: current situation and trends in the field of innovation and technology, both related to products and production systems;
  - Market: consumer market profile, competition, level of current consumption, emerging markets, etc.;
  - People: human needs, labor availability and skills;
  - Services: availability and quality of services and production factors necessary for proper industrial performance;
  - Sustainability: awareness on environmental aspects related to industrial activities;
  - Infrastructure: evaluation of structures for production flow and material distribution, power supply, information and telecommunications networks;
  - Economic and socio-political: understanding the impacts of legislation and regulations (fiscal, operational, etc.) as well as industrial policies, financing sources and technical standards.
3. After defining the drivers, the team selected companies, whose managers participated in the interviews, in order to collect their perception on the above drivers in the rail sector.

From a list of about 46 companies, in-depth interviews were conducted with 18 industrial leaders, including directors, presidents and managers. The numbers of companies and managers that participated of the interviews include aeronautics and automobile, areas also targeted in the overall project but not discussed in this paper. The interviews ranged generally from 30 minutes to over an hour [20].

Among the selected companies, six units produce components for the railroad industry and one was related to transportation, maintenance and retrofit of machines and wagons. Three large companies were interviewed in Santa Catarina, and two multinational organizations, which assemble freight trains and underground trains, in São Paulo state. The President of the Brazilian Association of Railroad Industry (ABIFER) was also interviewed.

The interviews contributed to the trends development related to the emerging industries and for the perception of the current state.

4. From these interviews, key trends were generated. These trends along with findings from scientific papers, technical reports, news and articles, enabled the construction of a trend table related to the rail industry.
5. An expert panel was formed to analyze the trend table including entrepreneurs, researchers, and government institutions representatives, with over 80 members. The experts were from the emerging industries that include three areas: railway, aeronautical and automobile. Approximately, 10% of experts were or have been active players in the Railroad Industry in Santa Catarina.

The panel featured four key moments, followed by group dynamics:

- Socio-economic study: this presentation intended to point out the current situation of the sector, both in SC and in Brazil. In the sequence, the experts were asked to draw up a list of strengths and weaknesses of the industries.
- Future visions: views scenarios were defined after the trends presentation. From this exercise, the following views were developed:
  - Railway: Santa Catarina Industry will be able to provide technological solutions to the railroad industry.

- Critical factors: consider the main points to develop the visions. The following critical factors were identified:
  - Rail: market; public policies and investments; R&D and technology; people.
- Action plan: each guest panel was convened to develop a range of short (2014-2016), medium (2017-2019) and long-term actions (2020-2022), to address each of the pre-defined critical factors. These actions were then consolidated into the previously defined drivers and were included in TRM to the three emerging industries, above mentioned. In addition, the panel resulted in a report containing socio-economic data and trends presented to the experts [9, 10].

#### 4. RESULTS AND DISCUSSION

The Railroad industry TRM, as mentioned before, was the result of joint collaboration that involved FIESC, UFSC, entrepreneurs and experts of the railway industry identified as an emerging sector in the state. The roadmap structure aims to capture the richness of the stakeholders’ view on the industry development in the next 10 years.

As pointed by [21], the TRM does not present an overview of the industry in a linear view, as it does not know the future, paths to be taken and events that occur over time. Instead, TRM route intends to act as an instrument to think of the future and support the decisions to be taken for the emerging industry. TRM is rich in information, as it is resulted from interviews, workshops with experts and literature. The expert panel pointed out the vision for the railroad industry as: the industry in Santa Catarina, qualified enough to provide technological solutions for the railroad industry. As shown in Table 1, seven key issues were identified as well as a set of actions that need to be developed to overcome those key issues. Table 1 shows the final TRM version.

Table 1

Roadmap for the railway industry in Santa Catarina, Brazil (Part 1)

RAIL				
		2014 - 2016	2017 - 2019	2020 - 2022
Market	Format disclosure policy railway vocation of the SC state			
	Develop workshops specifically for the railway industry			
Infrastructure	Invest in different market niches within the industry			
	Participate in events of international rail sector (industry visibility)			
	Support the development of components for railway industry			
	Form partnerships to attract investments from other countries			
	Integrate different industry sectors to optimize product lines			
	Promote coordination of national and international players with Santa Catarina companies to generate joint ventures in the railway sector			
Infrastructure	Eliminate bottlenecks in existing railways in SC (removal of rights of way and pass level)			
	Retrieve existing rail links			
	Build rail outline in the following cities: Joinville, São Francisco do Sul, Tubarão and Araquari			
	Increase the supply of railways for passenger transport			
	Build rail access to mines			
Infrastructure	Perform technical mission to meet the railway productive structure of countries with consolidated structure (Japan, Germany)			
	Integrate the road-rail network			
	Invest in new movement extensions in order to build new distribution centers by railway			

Table 2

## Roadmap for the railway industry in Santa Catarina, Brazil (Part 2)

RAIL			
	2014 - 2016	2017 - 2019	2020 - 2022
Technology	Plan the development of new sustainable technologies	Set cooperation agreements between institutions and national and international companies to train innovation projects Create specialized laboratories to meet new demands Develop technology for the sector demands, such as cars and rails Insert technology in Santa Catarina industry combined with the production of parts or rail systems Developing software for the railway segments	Develop a skilled structure to provide technological solutions
Services	Attract suppliers of products and services: maintenance of systems, wagons, components, etc. Invest in the maintenance of existing railways Create R&D&I and certification centers	Build a productive chain to the railroad industry with local businesses and national and international partnerships	Export rail industrial services
People	Deploy centers of excellence in embedded technologies Create lines of research together with the Scientific and Technological Institutions (STI) companies and to master the technologies needed for the development of the railway sector Create postgraduate courses in the railway area Align the program of technical and higher education with industry demands Create a technological center for the industry, known for technology implementation in relevant markets	Make technological exchange to meet the production system in other countries Deploy technology center for rail studies	Develop and encourage training of R&D&I centers with industry-academia partnerships
Sustainability	Disseminate and encourage implementation of reverse logistics Studying sustainable cases deployed in the sector in other states Explore sustainable alternatives for the sector Develop sustainable plans to reduce the impact of the construction of railways Study cases of sustainable practices applied in other countries	Implement sustainable programs in the rail industry in the state Implement sustainable practices	

Table 3

Roadmap for the railway industry in Santa Catarina, Brazil (Part 3)

RAIL		2014 - 2016	2017 - 2019	2020 - 2022
Economic and Socio-political	Facilitate the provision of fiscal incentives			
	Develop policy (Agency) specific for the cargo sector, connecting different modes			
	Create lines of investment for industries that will operate in the manufacture of components for railways			
			Edit a new regulatory framework for the modal	
			Create public and private incentive program for industries that operate in the industry	
			Create a development agency headed by the industry	
				Establish international agreements and a plan to import/export rail industrial services

### 5. CONCLUSION

This article presented a long-term technology roadmap for the emergent industry of railway in Santa Catarina. The project used the model proposed by [13; 24], with adaptations in the suggested methodology, in accordance with the needs and available resources.

The paper presents TRM usefulness in a real roadmapping exercise, conducted in Brazil, with the aim to identify the main leverage points in order to develop and strengthen the railroad industry in Santa Catarina.

The data collected aids in concluding the sector is still in emerging level in the state. The main technology drivers were defined and three main macro trends were mapped: search for mobility alternatives with focus on sustainability; improve interaction among industries, universities and research institutes. These trends were related to more than one driver. The proposed actions were related to these macro trends, highlighting their importance for the industry future.

For the macro trend with regard to mobility alternatives, the final report proposed actions such as to prioritize embedded technologies market (market) and to increase the supply of railways for passenger transport (infrastructure). To focus on sustainability, the actions presented in TRM are the development of sustainable technologies (technology) for the railway industry.

Another macro trend indicates that a better collaboration between universities, companies and other institutions is necessary to improve and to strengthen the railway development in Brazil.

Finally, the project defined some other actions of short, medium and long terms to be taken to achieve the visions resulting from the expert’s panel. The next step is to develop a project to put these actions into practice and accompany them as they are implemented. For FIESC, this study was also essential to identify the key actions and mechanisms needed to leverage development in Santa Catarina, through the railroad industry and to increase the railway grid in the state for both cargo freight and human transportation.

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