INNOVATION PROCESS IN TRANSPORTATION: A STUDY ON THE USE OF TELEMETRY IN THE ARTICULATED BUS SYSTEM OF THE BRT-RJ

PROCESSO DE INOVAÇÃO NO TRANSPORTE: UM ESTUDO SOBRE O USO DA TELEMETRIA NO SISTEMA DE ÔNIBUS ARTICULADOS DO BRT-RJ

PROCESO DE INNOVACIÓN EN TRANSPORTE: UN ESTUDIO SOBRE EL USO DE LA TELEMETRÍA EN EL SISTEMA DE AUTOBUSES ARTICULADOS BRT-RJ

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ABSTRACT

Considering the economic scenario of recent years, the current low growth prospects for the country, the serious public security situation, the growth of home office work, and the emergence of new solutions that are changing the way people move around cities, innovative initiatives are necessary to guarantee the survival of companies and the continued provision of quality service to the population. To face this new reality, organizations must consider innovation as one of their main strategic drivers. The workforce must have its creativity stimulated, and interaction between different departments must occur more and more in order to jointly identify solutions that improve overall results. This project presents a study on innovation as a competitive differentiator in the articulated bus (BRT) segment in the Metropolitan Region of Rio de Janeiro, aiming to understand which factors make innovation a competitive advantage for this segment. Critical factors with a high impact on results were identified and – with the help of technology – monitoring and control methods were defined. Managers analyze the numbers and develop action plans to reduce poor performance by an employee or the misuse of a part, for example. The results prove the efficiency of this innovation and suggest that its large-scale application can be a critical success factor for the segment, aiming to guarantee the future of the transport system and the continued provision of quality services to the people of Rio de Janeiro.

Keywords: BRT Telemetry. Transportation System. Road Transport. Process Optimization. Innovation.

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RESUMO
Considerando o cenário econômico dos últimos anos, a atual baixa perspectiva de crescimento do País, a grave situação de segurança pública, o crescimento do home office e o surgimento de novas soluções que estão alterando a forma como as pessoas se deslocam pelas cidades, fazem-se necessárias iniciativas inovadoras para garantir a sobrevivência das empresas e a continuidade da prestação do serviço à população com qualidade. Para fazer frente a essa nova realidade, as organizações devem considerar a inovação como um dos seus principais direcionadores estratégicos. O quadro funcional deve ter sua criatividade provocada e a interação entre diferentes departamentos deve acontecer cada vez mais afim de juntos identificarem soluções que melhorem os resultados como um todo. O presente projeto apresenta um estudo sobre a inovação trabalhada como diferencial competitivo no segmento de ônibus articulados (BRTs) na Região Metropolitana do Rio de Janeiro, tendo como propósito compreender quais são os fatores que fazem da inovação um diferencial competitivo para esse segmento. Fatores críticos com alta participação nos resultados foram identificados e – com a ajuda da tecnologia – formas de acompanhamento e controle foram definidas. Gestores analisam os números e traçam planos de ação com o objetivo de reduzir a má operação de um colaborador ou a má utilização de uma peça, por exemplo. Os resultados comprovam a eficiência dessa inovação e sugerem que a sua aplicação em larga escala pode ser um dos fatores críticos de sucesso para o segmento, visando garantir o futuro do modal e a continuidade da prestação de serviços de qualidade para o povo da Cidade do Rio de Janeiro.

Palavras-chave: Telemetria BRT. Sistema de Transporte. Transporte Rodoviário. Otimização de Processos. Inovação.

RESUMEN
Considerando el escenario económico de los últimos años, las bajas perspectivas de crecimiento del país, la grave situación de seguridad pública, el aumento del teletrabajo y la aparición de nuevas soluciones que están transformando la forma de desplazarse en las ciudades, se requieren iniciativas innovadoras para garantizar la supervivencia de las empresas y la prestación continua de servicios de calidad a la población. Para afrontar esta nueva realidad, las organizaciones deben considerar la innovación como uno de sus principales motores estratégicos. Es necesario estimular la creatividad de la plantilla y aumentar la interacción entre los diferentes departamentos para identificar conjuntamente soluciones que mejoren los resultados generales. Este proyecto presenta un estudio sobre la innovación como diferenciador competitivo en el segmento de autobuses articulados (BRT) de la Región Metropolitana de Río de Janeiro, con el objetivo de comprender qué factores convierten la innovación en una ventaja competitiva para este segmento. Se identificaron factores críticos con un alto impacto en los resultados y, con la ayuda de la tecnología, se definieron métodos de seguimiento y control. Los gerentes analizan las cifras y desarrollan planes de acción para reducir, por ejemplo, el bajo rendimiento de un empleado o el uso indebido de una pieza. Los resultados demuestran la eficacia de esta innovación y sugieren que su aplicación a gran escala podría ser un factor clave para el éxito del segmento, con el objetivo de garantizar el futuro del sistema de transporte y la prestación continua de servicios de calidad a los cariocas.

Palabras clave: Telemetría BRT. Sistema de Transporte. Transporte por Carretera. Optimización de Procesos. Innovación.

1 INTRODUCTION

Within a process of continuous improvement, aiming to obtain better results and face the current economic crisis, urban passenger transport companies have prioritized the search for innovation and cutting-edge technological solutions to improve their results. Bus Rapid Transit (BRT) was an urban mobility solution that emerged – first in Brazil – in 1974, with the Integrated Transport Network (RIT) in Curitiba (Paraná). The first BRT/RJ corridor in operation in Rio de Janeiro (RJ) was the TransOeste, whose initial phase was inaugurated in 2012.

Currently, in Rio de Janeiro, the system has a fleet of 440 articulated buses that circulate through the corridors of TransOeste (60 km), TransCarioca (39 km) and TransOlímpica (26 km). According to BRT/RJ data, a bus replaces 126 cars, on average. The system has 125 km of exclusive corridors, 2,100 employees and about 450 thousand passengers per day (Figure 1). In Rio de Janeiro, the BRT/RJ is managed by a consortium (private passenger transport companies) and, currently, the system is already present in 140 countries around the world.

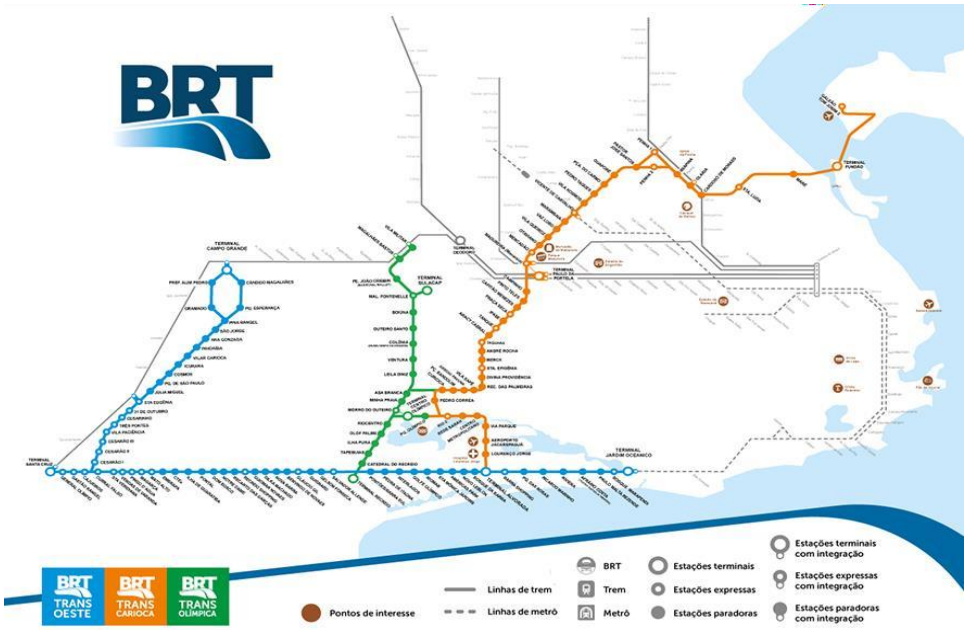
In order to improve its performance, Auto Viação Tijuca S.A. (Tijuquinha) entered into a partnership with Viação Normandy do Triangulo Ltda. (Normandy), and the Tijuquinha/Normandy group decided to seek, through innovation, a competitive advantage that would promote a reduction in its operating costs and bring an increase in the quality of services.

The Application Project will address the way innovation is perceived by urban passenger transport companies, highlight Knowledge Management and cite Schumpeter (1997), the sources and paths of innovation, and the barriers. It will present the economic scenario of the city and the State of Rio de Janeiro and the crisis that affects the country as a whole, in addition to describing the application of telemetry and the various benefits achieved with the use of this technology.

At the conclusion of the work, we will project the benefits of extending the technological solution applied in the Tijuquinha/Normandy partnership to the other companies of the BRT/RJ System of the City of Rio de Janeiro and the importance of metropolitan transport management in the coordination of mobility actions and in the dissemination of good practices, making urban transport companies viable and bringing improvements in the quality of life of the population.

Figure 1

Infographic of the BRT/RJ corridors and the interconnection with the train and subway modes



Source: BRT/RJ (2022).

The present study analyzes the use of telemetry in the articulated bus system of the BRT-RJ, as well as the difficulties and benefits that the implementation brought to the road passenger transport companies in the Metropolitan Region of Rio de Janeiro.

This study aims to analyze the feasibility and applicability of the use of telemetry in the BRT/RJ modal.

2 THEORETICAL FRAMEWORK

To use innovation in the best possible way, it is first necessary to understand where it was born in the business model and what are the fundamental steps to develop it in this organizational environment.

Based on the theories of economist Schumpeter (1997), considered "the father of innovation", the process of knowledge and innovation management, its sources, the barriers to be faced, the process of performance analysis and the direct and indirect results of innovation will be discussed.

2.1 INNOVATION

For Schumpeter (1997), innovation can be understood as the fundamental impulse that initiates and maintains the movement of the capitalist machine, from which derive "new consumer goods, new methods of production or transport, new markets, new forms of industrial organization that the capitalist company creates".

This phenomenon, which is dynamic and constant, non-linear, is a fundamental sociological factor in the reproduction of new patterns and influenced by several other factors. Innovation causes changes and transformations and takes place from the interaction between social actors to the processes of the organizational structure and the economic, political and social environments.

The socio-cultural environment in which the organization operates, that is, the environment where social, cultural and institutional transformations occur, in Schumpeter's view, is one of the important components of innovation. For Schumpeter (1997), it means making new combinations, that is, doing things differently, which encompasses:

a) create a new good not yet familiar to consumers, or a new quality of a certain good;
b) to introduce a new method of production, practically unknown within a certain branch of production, which does not need to derive from a scientific discovery;
c) opening a new market, to which the product of a given industry has never had access before, regardless of whether or not this market has previously existed;
d) discover a new source of raw material or semi-finished products, too, regardless of whether or not that source has existed previously, and
e) reorganize any industry, with the creation or rupture of a monopoly position.

To innovate, it is not enough, therefore, for the organization to develop different behavior, but also to seek novelties that add value, in the sense of enabling leverage for future innovative processes.

According to Schumpeter (1997), innovation produces a continuous industrial mutation that constantly revolutionizes the economic structure from within, incessantly destroying the old and incessantly creating a new one.

The author calls this process Creative Destruction, in which there is a continuous search for the creation of something new, which destroys old rules and establishes new ones, which he considers an essential factor about capitalism.

Innovation, says Alter (2005, p. 155), when referring to Schumpeter's idea of Creative Destruction, rests on the simultaneous development of forces of destruction and creation, forming a permanent movement, a constant change that mobilizes a set of actors.

The encounter between organization and innovation, the author continues, corresponds to the relationship between established social practices and the forces of transformation, generating a movement of complex relations in permanent tension.

There are contexts in which the tendency to innovation is greater than in others, which makes it possible to infer that values, norms and social rules need to be taken into account

in order to think about this phenomenon, which fundamentally depends on a process of cultural acceptance.

Thus, it is necessary to view innovation as the result of a sum of variables (internal and external to the organizational group), responsible for the new directions of a company's development, and for the supply of the needs exposed in each specific context. For Freeman and Soete (1992, p. 19), innovations "make it possible to modify the entire quality of life for better or for worse and can involve not only greater quantities of the same goods, but also standards of goods and services that have never previously existed, except in our imagination".

Thus, innovation represents a creation, a movement that, according to Alter (2005), mobilizes a set of actors, enabling the transformation of social relations into new ones.

conducts. In the course of these relationships, meanings are generated, that is, the intentions, motives, and attitudes of the actors, giving rise to organizational practices.

These practices, which Dupuis (2007) characterizes as contextualized, contain a culture to the extent that they make sense to the actors.

In this perspective, innovative practices indicate cultural manifestations, enabling the organization to innovate based on the actions of its social actors.

2.2 KNOWLEDGE MANAGEMENT AND INNOVATION

Innovation studies have drawn on a wide range of disciplines, such as management, economics, geography, sociology, and psychology, as well as adopting different methods and definitions.

This diversity of research limits the accumulation of knowledge about innovation management and makes it difficult to define some measures of performance or success, which makes it difficult to translate it into managerial practices (TIDD, 2001).

The challenge of innovation management is to build organizations in which innovative behavior thrives, recognizing people as its main asset, since innovation is increasingly related to teamwork and creativity (TIDD, 2001). Knowledge management is responsible for creating ideas and concepts in the organizational context, which are incorporated into pioneering technologies, products, and services that meet the demands of customers and society. This new knowledge is disseminated to the entire organization and external environment, representing a process of continuous innovation that generates sustainable and lasting competitive advantage (NONAKA et al., 2000).

Despite the recognized importance of knowledge as a vital resource for organizational performance, there is little understanding of how organizations actually create and manage it dynamically.

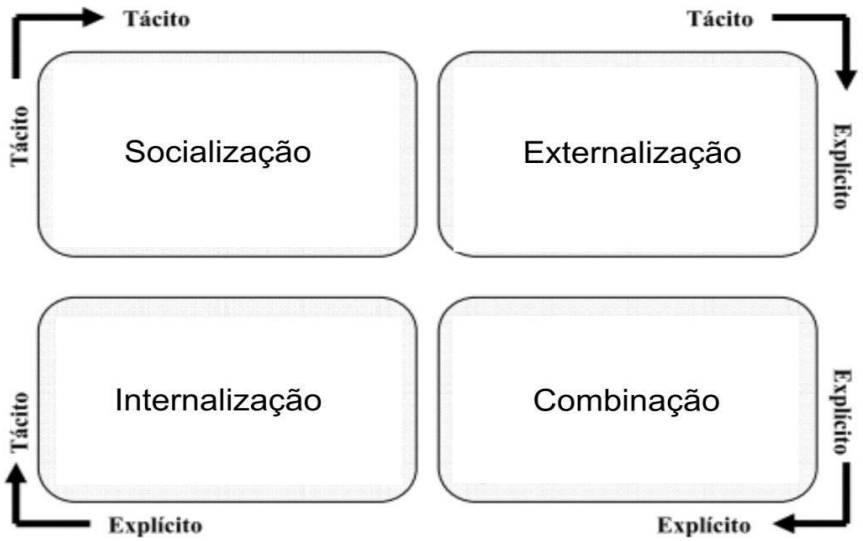
In a competitive environment in which the only certainty is uncertainty, the ability to create and use knowledge is the most important source of sustainable competitive advantage for companies, which are seen as a dynamic, evolved and almost autonomous system of production and application of knowledge (NONAKA; TAKEUCHI, 1997; NONAKA et al., 2000; SPENDER, 1996; ALAVI; LEIDNER, 2001).

There are two types of knowledge: tacit and explicit. Tacit knowledge is represented by the cognitive dimension, technical ability, know-how, experience, mental models, beliefs and values, and is available to people, and is difficult to be communicated and formalized in concrete means.

In turn, the explicit, because it is formal and systematic, is easily processed, shared, and stored in documents, manuals, databases, and other media. The Knowledge Spiral model – Socialization, Externalization, Combination and Internalization (SECI) – presents the conversion of knowledge from tacit to tacit (socialization), from tacit to explicit (externalization), from explicit to tacit (internalization) and from explicit to explicit (combination), as shown in Figure 2 (NONAKA, 1994; NONAKA et al., 2000).

Figure 2

SECI model of knowledge conversion



Source: Nonaka (1994) and Nonaka et al. (2000).

The SECI model can be understood as the organizational capacity to create knowledge, disseminate it in all areas and incorporate it into goods, services and systems

(Johannessen et al., 1999). It represents a dynamic process in which the organization creates, maintains and exploits knowledge (NONAKA et al., 2000).

In order to understand how organizations create knowledge dynamically, in addition to the SECI model, there are two other elements in interaction: the ba – a word of Japanese origin that represents the dynamic and shared organizational context in the processes of creation, dissemination and use of knowledge – and knowledge resources – inputs, outputs and moderate factors of the knowledge creation process (NONAKA; KONNO, 1998; NONAKA; TOYAMA, 2003; NONAKA et al., 2000).

Knowledge resources are stimulated and shared in ba, in which the tacit knowledge present in individuals is converted and amplified by the Knowledge Spiral through socialization, externalization, combination, and internalization. Leadership has the function of facilitating the process of knowledge creation (NONAKA et al., 2000).

Characterized by the dynamic interactions between the members of the organization and between these members and the environment in which they are inserted, the process of knowledge creation improves the interaction between individuals, organizations and society, to the extent that it expands the conversion from tacit to explicit knowledge. In the organizational environment, it is relevant to transform individual learning into collective learning and to create knowledge continuously (NONAKA, 1994; NONAKA et al., 2000).

Innovation management is the result of a kind of corporate project, translated into strategies and operations in order to create something that adds social value or wealth to organizations. The innovation process, which must be planned and managed, involves knowledge, information and creativity (TIDD et al., 2005).

A review by Tidd (2001) suggests that the complexity and uncertainty of the environment affect the degree, type, organization, and management of innovation, and that greater adjustment between these factors or greater coherence of the organizational configuration leads to better corporate performance. Innovation has two fundamental dimensions: novelty and feasibility (GARCIA; CALANTONE, 2002).

Novelty is related to knowledge, as it is the result of the creation of new ideas and concepts, that is, of people's creativity, evidencing the relevance of tacit knowledge and the SECI process of knowledge conversion (GRANT, 1996; NONAKA, 1994).

In turn, the feasibility of the ideas and concepts generated are more related to the Product Development Process (PDP). Innovation and process improvement play strategic roles and refer to corporate learning, both in the sense of knowledge acquisition and exploration.

In this way, the correspondences between the organization's structures, processes and culture, opportunities and characteristics of technological innovation, as well as the competitive and technological scenario in which the organization operates are explored (TIDD, 2001; TIDD et al., 2005).

2.3 TYPES OF INNOVATION

Innovation varies in its scope, execution time, and organizational and social impact. Categorization of any kind usually involves areas of duplication, in which the barriers between one category and another overlap. We will get an overview of the main types of innovation and a simplified classification. We must also take into account that categorizing innovation is not a science, and it can be positioned in different categories by companies.

The OECD - Oslo Manual provides a broad definition of what innovation is and its types.

According to the document:

> The implementation of a new or significantly improved product (good or service), or a process, or a new marketing method, or a new organizational method in business practices, in the organization, in the workplace, or in external relations is what is called innovation. (OECD, 1990, p. 55)

a) PRODUCT INNOVATIONS – Related to the provision of a new product/service, for example, a new insurance, a new line of financing, the service of a new medical specialty.
b) PROCESS INNOVATIONS – Related to the modification of procedures prescribed for the elaboration/production of a product/service (back office) or procedures for user/customer service and service delivery (front office).
c) MARKET/MARKETING INNOVATIONS – Related to the discovery of new markets, to the identification of niches in the same market, or even to the change in the organization's behavior in the market in which it operates.
d) ORGANIZATIONAL/MANAGERIAL INNOVATIONS – Related to the introduction of new store formats, new planning techniques, process management, adoption of indicators, among others.

2.4 SCHUMPETER AND THE FIVE WAYS

Joseph Alois Schumpeter (1883-1950) was one of the most brilliant economists of the twentieth century. He is the father of the theory of "Creative Destruction", which states that

the capitalist system progresses by constantly revolutionizing its economic structure: new companies, new technologies and new products constantly replace old ones (Figure 3).

Figure 3

Schumpeter's Waves

Source: Schumpeter (1997).

According to Schumpeter (1997), there are five possible paths of innovation:

a) Introduction of a new good or a new quality in an existing good.

b) Introduction of a new production method.

c) Opening of a new market.

d) Conquest of a new source of supply of raw materials or semi-manufactured goods.

e) Establishment of a new organization in any industry.

Innovation, for Schumpeter (1997), is "the fundamental impulse that initiates and maintains the movement of the capitalist machine". He reinforces that innovating means making new combinations:

> Create a new good not yet familiar to consumers or a new quality of a certain good; to introduce a new method of production, practically unknown within a certain branch of production that does not need to derive from a scientific discovery; to open a new market to which the product of a given industry had never had access before, regardless of whether this source had existed or not before; reorganize any industry, such as the creation or rupture of a monopoly position. (SCHUMPETER, 1997).

Schumpeter (1997) states that innovation generates a continuous industrial mutation, which alters the bases of the economic structure because of Creative Destruction. It reinforces that it is the continuous search for the creation of something new, which destroys old rules and creates new ones, which is vital for capitalism.

Schumpeter (1997) argues that "market innovation" is an organizational strategy, as it is about winning customers through products with lower prices. Encouraging the continuous production of innovations is presented as a possibility of obtaining competitive advantage. According to the economist (SCHUMPETER, 1997):

> The insertion of new practices in Brazilian organizations, such as corporate education, which involves, among other technologies, the modality of distance training, develops competencies that allow the acceptance and implementation of new social practices.

The author believes that this generates motivation in the search for differentiation, creation and implementation of organizational practices of organizational development, which, according to his beliefs, can be seen as the so-called "Creative Destruction", or even as "spontaneous and discontinuous changes implicit in the process of economic development" (SCHUMPETER, 1997).

2.5 THE SOURCES OF INNOVATION

Peter Drucker (2004) suggests seven types of sources of innovation, four of which are within organizations or sectors themselves. They are: process needs, unexpected occurrences, sectoral changes and inconsistencies. The other three that are outside of organizations and the industry are changes in perception, demographic shifts, and new knowledge. Please note:

- Process needs – It is innovation that is based on adjustments in processes.
- Unexpected occurrences – The unexpected is the source of opportunity for innovation.
- Sectoral and market changes – Drucker (2004) exemplifies with privatizations. They happen when social structures or markets change.
- Incongruities – These are inconsistencies. They happen when a product or service does not meet the expectations of its customers adequately and then, naturally, a change is necessary.

As for those outside organizations and/or the sector, it is worth mentioning:

- Changes in perception – They do not alter the facts, but they alter their meaning. Drucker (2004) exemplifies with the "computer".
- Demographic changes – This is the most reliable source for the author. These are the innovations created from the change in the total number of people, in age distribution, occupation, education and geographic location. This source is one of the most rewarding and least risky of entrepreneurial initiatives.

The main sources of innovation in companies are:

- Employees from different sectors within the company itself.
- Patent or know-how licenses.
- Research and Development Department of the company itself.
- Specialized publications in technical magazines.
- Fairs and exhibitions.
- Suppliers of machinery, equipment, materials, components/software.
- Research Institutes or Technology Centers.
- Trainings, conferences and lectures.
- Competitors.
- Other companies in the same economic group.
- Customers and end consumers.
- Universities and other institutes of higher education.
- Consulting firms or independent consultants.

2.6 OPEN INNOVATION

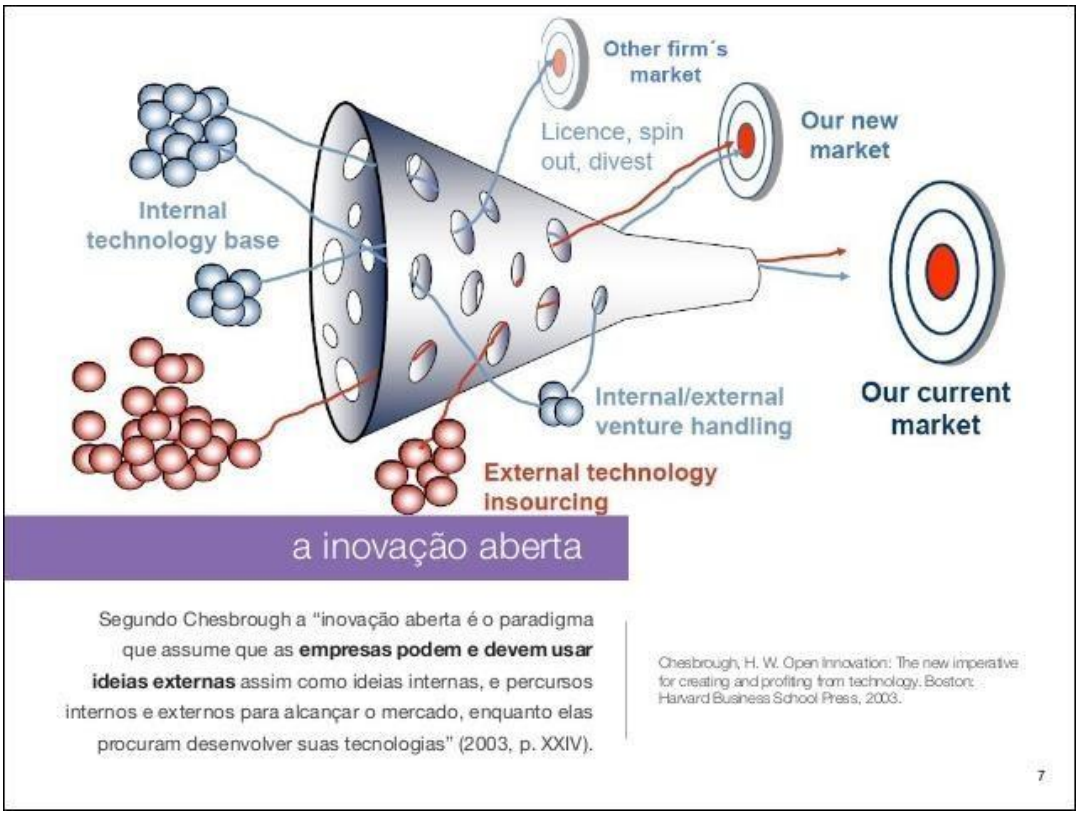
Chesbrough (2012) argues that there are two paradigms with regard to innovation: closed innovation and open innovation. The closed one is the one that focuses on internal Research and Development. This model of innovation was justified in industrial secrecy.

The open one is more current, arguing that organizations can create mechanisms for interaction with the external environment, for example: university laboratories, institutions focused on research, customers and suppliers. This paradigm is based on collaboration and uses the internet as fuel for this.

Chesbrough (2012) states that organizations that opt for the so-called open innovation are more likely to succeed in innovations (Figure 4).

Figure 4

Open innovation



Source: Chesbrough (2012).

Henry Chesbrough (2012) coined the term "Open Innovation", which argues that companies can and should use external ideas, as well as internal ones, and internal and external paths to reach the market, while developing their technologies. In this model, organizations can commercialize internal or external technologies and use internal or external resources in the execution of projects.

As a characteristic of open innovation processes, projects can be initiated by the company itself or by other external actors, as well as be incorporated or transferred to other organizations, at different stages of development.

Felin and Zenger (2014) evaluate open innovation as being capable of greater success in the face of environmental challenges, which demands a new managerial profile.

The principles of open innovation are:

- Not all of the best work with us. We need to count on the best inside and outside our company.
- Research and Development can create significant value. In-house R&D is needed to achieve some of that value.
- We are not obliged to generate research in order to profit from it.
- Building a better business model is more useful than getting to market first.

- If we make the best use of internal and external ideas, success will be ours.
- We have to produce revenue from the use of our patents by third parties, and we must buy third-party patents whenever it improves our business model.

2.7 BARRIERS TO INNOVATION

Each organization sees "innovation" in a particular way. Because of this, barriers exist and must be overcome.

As in the vast majority of times the time between the beginning of the process and the return on investment is medium or long term, the barriers are numerous and need to be identified and worked on. We can group them into three major groups:

- 1 - Of a technological nature.
- 2 - Of an economic and financial nature.
- 3° - Of human nature.

For Silva and Takeda (2005), norms, assumptions and values can be examples of barriers to innovation, so a behavioral and attitude change is necessary, especially with regard to human skills and the environment, so that it is flexible and entrepreneurial. They used a questionnaire to identify barriers to innovation and concluded that negative cultural orientation is the main one.

Kaasa and Vadi (2010) point out that culture can unify behaviors and people, as well as be a barrier between them. They add that "culture affects innovation because it shapes patterns of dealing with novelty, individual initiatives and collective actions, and understandings and behaviors in terms of risks as well as opportunities." (KAASA; VADI, 2010, p. 584).

Hernandéz-Mogollon et al. (2010) tested the role of cultural barriers in the relationship between open-mindedness and organizational innovation.

Regarding the evaluation of cultural barriers, they created five items from the reviewed literature, which dealt with resistance to change, training, lack of adjustment to the new culture, difficulties in assuming new patterns of behavior, and little satisfaction and/or integration of personnel.

In fact, the biggest barriers to innovation are within the organizations themselves, strongly alive in their organizational cultures and in their own work routines. The main ones are:

- Cultural barriers: prejudices, lack of cooperation, trust and team spirit among employees, resistance to change, a work environment that is not harmonious and cohesive, etc.
- Perceptual barriers: difficulty in distinguishing the essential from the accessory, tendency to overcomplicate or oversimplify problems, inability to view the issue from different perspectives, saturation, seeing what one expects (or wants) to see instead of reality, and lack of proper use of the various sensory stimuli.
- Emotional barriers: fear of making mistakes, fear of "ridicule", inability to tolerate ambiguity, preference for judging ideas instead of generating them, lack of interest and motivation, fear of being misunderstood, etc.
- Intellectual barriers: inadequate choice of mental processes, lack of knowledge, dissonance between tasks and skills, lack of clarity in communication, lack of commitment and critical and reflective capacity.

2.7.1 Internal

The most common internal barriers encountered in organizations are:

- Cultural restrictions.
- Investment limitations.
- Internal problems with the workforce.
- Inadequate processes.
- Inflexible infrastructure.
- Limited access to information.

2.7.2 External

The most common external ones are:

- Government and other legal restrictions.
- Economic instability.
- Inadequate technology.
- External problems with the workforce.

2.7.3 Management System Performance Analysis and Innovation

Organizations, due to market needs, seek a system to manage innovation, as well as seek perspectives for business sustainability, whether through products, processes, services, market conquest or organizational changes. After all, if they do not change, "they run the risk of being surpassed by others that do" say Bessant and Tidd (2009 In: RAI, 2015).

There is no way to evaluate the performance of an innovation process without the right indicators. According to Bes and Kotler (2011), "measures are essential, it is not possible to measure, it is not possible to manage and improve".

For Makkonen and van der Have (2013), in the journal RAI, there is no consensus on which indicator should be used to measure innovation, due to its complexity. The most used to evaluate the performance of an Innovation Management system are profitability, productivity, and market share.

In addition, the form of investigation or evaluation and the conclusion must also be well measured by the most correct instrument, as the information collected can make the organization direct its physical, financial and personnel efforts to a destination that leads to the "non-sustainability" of the business, or to a result that generates wrong decision-making. causing financial, motivational and loss of market damage.

In the text "Business Performance: a comparison between subjective and objective indicators", it is possible to understand that "Strategic Management often finds it difficult to obtain valid objective data for measuring business performance, as well as to define which performance indicators best represent the overall performance of companies." (GATTERMANN; SAMPAIO, 1999)

The authors also list some possibilities for using the most used indicators in the market to measure business performance, such as market share, Return on Assets (ROA), Return on Investment (ROI), profitability (profit on sales), growth, market performance, sales growth rate, product quality, size, relative success of new products, consumer satisfaction and overall performance (GATTERMANN; SAMPAIO, 1999, p. 2).

According to Tidd et al. (2008), we can use specific measurements to evaluate the internal workings of the innovation process, such as:

- Number of new ideas (product/service/process) generated at the beginning of the innovation system.
- Failure rate – in the development process, in the market.
- Number or percentage of extrapolation in development time and cost budget.
- Measuring customer satisfaction ratings – was that what the customer wanted?
- Time to market (average, compared to industry standards).
- Involvement of people/hour per innovation carried out.
- Average time from innovation process to launch.
- Continuous improvement measurements – suggestions/employee, number of problem-solving teams, accumulation of savings per worker, cumulative savings, etc.

2.7.4 Direct and Indirect Results of Innovation

In Salum et al. (2012), we can see that there is still a lot of discourse and little action in medium-sized companies when it comes to innovation.

The lack of knowledge of their role can contribute to companies still not prioritizing strategy and not organizing organizational goals for their growth and positioning in the market. Salum et al. (2012) explain that "it is necessary to face the theme as a new perception, treating innovation as a priority and also as an option for growth."

We highlight some results of Innovation Management, when the company seeks a position in the market, such as:

- Established and productive internal processes.
- Knowledge management as a way to organize ideas.
- Image of the company to its peers and customers.
- Internal and continuous improvements.
- More organized and dynamic indoor environment.
- Well-communicated and structured organizational culture.
- Cost reduction.
- Openness to new partnerships for innovation.

3 METHODOLOGY

In this chapter, the research methodology to be followed to analyze the innovation project will be presented and whether the objective of improving the performance of the company BRT Tijuca/Normandy, by implementing the system with Telemetry, has been meeting the company's expectations.

The research methodology, according to Castro (2002), is the space in which the necessary means to observe reality in a systematic and disciplined way must be outlined, in the sense of observing the facts, analyzing the relationships between them and, finally, responding to the research problem that represents, for the researcher, a gap in knowledge. Castro (2002) and Gil (1999) indicate three types of research: Exploratory, Descriptive and Explanatory.

The present project was based on a qualitative descriptive study, because, according to Perovano (2014), the descriptive process seeks to identify, record and analyze the characteristics, factors and/or variables that are related to the phenomenon studied. This type of research can be seen as a "case study" in which, after data collection, an analysis of the relationships between the responses is carried out for a subsequent projection of the expected effects on a company, product or production system.

Descriptive research can be:

- Documental.
- Field studies.
- Interviews.

It is important to emphasize that the researcher does not interfere in reality, he only observes the variables that, spontaneously, are linked to the phenomenon under study.

In descriptive research, the object of the investigation is partially known. The primary objective of research of this type is to describe the characteristics of a certain group or phenomenon, or to establish relationships between variables. It involves planning and standardized data collection techniques. Descriptive surveys are the most requested by organizations such as educational institutions, commercial companies, political parties, etc.

Qualitative research focuses on apprehending facts and phenomena, and not merely recording or describing them. It is focused on the perception of reality, and the most common type of this research in the social sciences is the Case Study. Quantitative research, on the other hand, expresses a strong concern with the measurement and establishment of relationships and determinations of some facts or phenomena of social reality. It is relevant to state that research can be, at the same time, quantitative and qualitative (TRIVINOS, 1987). In practice, the researcher, who develops an investigation based on statistics, intends to obtain objective results, fixing the result in the statistical data. However, this information could be used to advance a broader interpretation of the result.

According to the studies described, the methodological approach chosen to be used in the present study will allow us to portray the largest number of elements existing in the reality studied. However, to carry out the research in full, we used qualitative techniques with interviews.

The interview is an indirect observation. It is one of the most used techniques in social research and consists of interaction with the participant, formulating questions with the objective of obtaining data for the investigation.

Document analysis is an important technique in qualitative research, either complementing information obtained by other techniques, or unveiling new aspects of a theme or problems, according to Krippendorff cited in Lüdke and André (1986).

The strategy for collecting information was based on semi-structured interviews, as it arouses the interest and collaboration of the interviewee.

The semi-structured interview sought to bring perceptions and opinions about the company's decision to implement, as well as the vision of each manager and their

expectations about the innovation project. The first interviewee was the Legal and Administrative Manager of the company BRT Tijuca/Normandy, responsible for collecting the data, interviewing the managers of the areas involved and with the company that supplied the applied technology, M2M, in addition to being the interlocutor of the working group with the company. The complete interview questionnaire is presented in Appendix A of this study.

The interview was conducted through a structured questionnaire with the general data of the interviewees: company, name of the interviewee, position, date of the interview, time in the company and time in the position. In addition, the motivations for implementation, the stages of the implementation and the expected and obtained results were questioned.

To collect the information, the methodology of the interview survey was used, and applied by Cleber Reis, Legal and Administrative Manager of the BRT Tijuca/Normandy company and representative of the working group of the Application Project.

In this model, the researcher actively participates in the research situation, assuming, in a way, the role of a member of the group that is being observed.

We have a member who is a collaborator of the researched company, so the interaction and internal perception in this case study were faster, since it was possible to access internal documents, static data and percentage of return from the implementation.

The interview was conducted with Cleber Reis, Legal and Administrative Manager, Rosane Lucena, Operational Manager and Alvimar Queiroz, Maintenance Manager, all from the company BRT Tijuca/Normandy, and Flavio Mousinho, Operations Manager, and Alexandre Pereira, Operational Consultant of the company that provides the Telemetry system, M2M Solutions.

According to Marconi and Lakatos (2001), the questionnaire is a scientifically developed instrument, composed of a set of questions ordered according to a predetermined criterion, which must be answered without the presence of the interviewer and which aims to collect data from a group of correspondents. This instrument aims to capture the opinions, beliefs, feelings, interests, expectations and perceptions of the respondents in a uniform manner.

Based on this definition, we based our study on a questionnaire to collect detailed information on the implementation process, valid training, technical feasibility, benefits and financial results.

The interview was applied in a non-face-to-face manner, delivered by e-mail from 07/27 to 07/30/2018 to all managers, and doubts were clarified by telephone.

With the feedback of the interviews, by e-mail, the data were consolidated by the working group. The interpretation occurred taking into account the difficulties encountered by

each area involved with the relevance of the answers, thus demonstrating the feasibility of implementing the system in the company and, in the future, in others that operate the same transport system.

The employees of the company BRT Tijuca/Normandy are characterized by the length of time at home, coming from the base companies Auto Viação Tijuca S/A = Tijuquinha and Viação Normandy do Triângulo LTDA = Normandy. Cleber Reis, Legal and Administrative Manager, has been in the BRT system for a year and eight months, but in the group of companies for more than 8 years; Rosane Lucena, Operational Manager, has been in the group for 20 years and in the Tijuca/Normandy BRT for 2 and a half years; Alvimar Queiroz, Maintenance Manager, at BRT Tijuca/Normandy for 2 and a half years. All of them were comfortable with the possibility of innovation, a striking characteristic in the group's companies, and were concerned about the financial results of the project and how the implementation is linked to the customer. They talk about organizational data in a transparent way.

The company of Flavio Mousinho, Operations Manager and Alexandre Pereira, Operational Consultant, supplier of the Telemetry system, M2M Solutions, with 15 years of experience in the market, has consolidated itself as one of the main fleet monitoring companies in Brazil. It monitors more than 20 thousand vehicles in Brazil and abroad, with more than a thousand BRT buses in Rio de Janeiro, one of the most modern in the world. Because it is a company that thinks of innovation as a proposal for intelligent solutions, Alexandre was in tune with the company's expectations.

Table 1

Summary Table

Nature of the research	Research universe	Sample of the survey	Data collection	Interviewees
Qualitative descriptive research	Companies operating in the BRT system Tijuca/Normandy and the equipment supplier	Companies responsible for the implementation of the Telemetry Project	Semi-structured interviews	Managers responsible for the areas involved with the implementation of the Telemetry project.

Source: Adapted from Barbosa (2015, p.53).

4 DATA ANALYSIS AND DEVELOPMENT OF THE SOLUTION PROPOSAL

4.1 TELEMETRY

Telemetry: "tele" means "remotely" and "metria" means "measurement". It is a technological monitoring system used to command, measure or track something from a distance, through wireless communication (radio or satellite signals). Telemetry is currently

applied in many branches, such as agriculture, meteorology, water and sewage treatment system, energy monitoring, etc. For some time now, it has been helping to monitor and increase performance, such as in Formula 1 cars. In the late 80s, when Senna raced his McLaren, after practice he spent hours in the "motorhome" analyzing the data.

Transport companies are also investing in this technology, and today it is possible to know details about fuel consumption, wear and tear of parts, sudden acceleration and braking, intensity of curves and other driving details. In this way, companies are able to monitor and correct employee behaviors in various aspects.

The telemetry project is part of an internal campaign by MobiBrasil, called Conscious Driver – Do the Right One. The theme was adopted in September 2017, to stimulate individual changes in employees, with the aim of achieving results collectively.

MobiBrasil, an urban transport company in São Paulo, set a goal for diesel savings and awarded 80 drivers who managed to reach the determined amount. Fuel consumption was measured using telemetry technology, which was deployed on four of the company's lines in September 2017.

In addition to saving fuel, MobiBrasil stopped emitting 107.46 tons of CO2 into the environment, just with the program implemented in these four lines for four months. The numbers were provided by the CEO of MobiBrasil Niege Chaves, Jessica Marques, for Diário do Transporte (2017).

Another transport company, Viação Santa Brígida, which operates urban lines in the north, northwest, southeast and central regions of the City of São Paulo, invested in telemetry to improve the management of passenger transport fleets.

According to Fernando Cesar, maintenance manager at Viação Santa Brígida, the company already knew telemetry previously when participating in a project whose objective was to treat the technology intelligently. Using the concept of information transmission, the project allowed to aggregate the treatment of the data collected, understanding what to do with each result. "The items collected in the project were excessive speed, sudden acceleration, sudden braking, sudden turning, excessive rotation and driving outside the green lane," said Fernando Cesar.

There were two phases in this period. In the beginning, we sought to understand how telemetry technology would work in a situation where the driver operated the bus without knowing that he was being monitored. "In the next phase, already aware of the project, the driver acted with knowledge of which driving events were being analyzed."

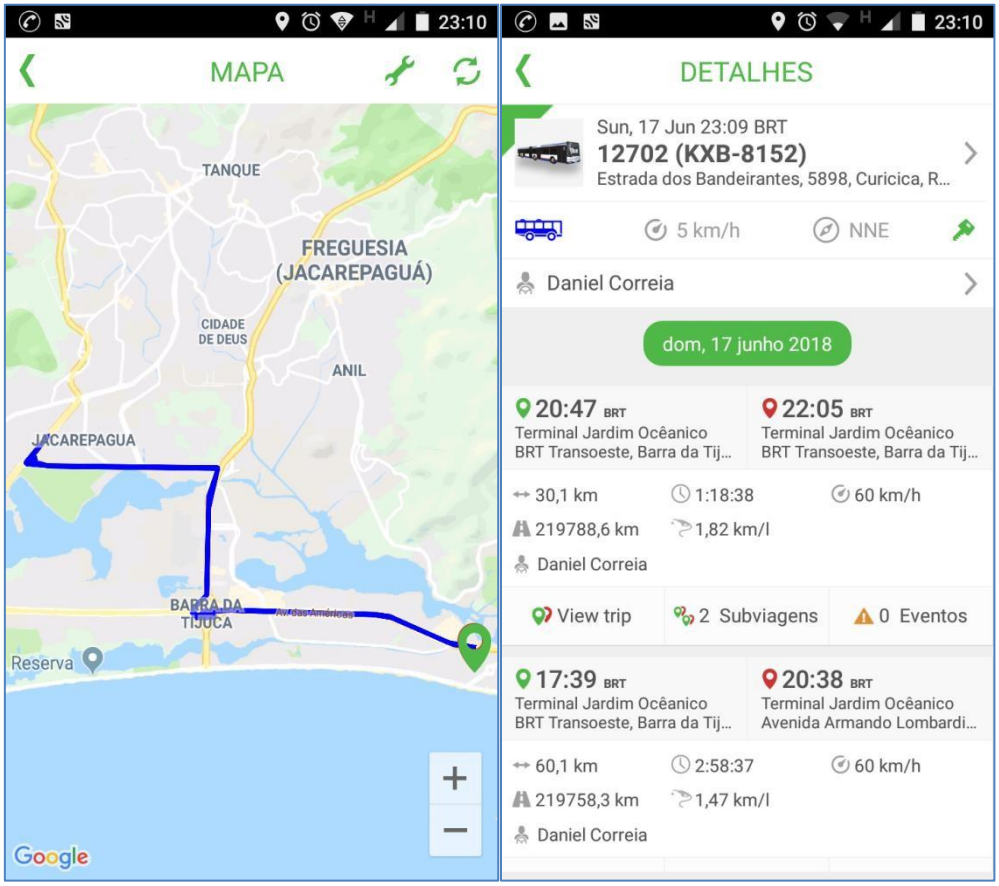
4.2 THE MOST COMMON USE OF TELEMETRY

Telemetry is widely used abroad with significant results in cost and labor reduction. The reduction in costs happens in several ways:

- Identification of the driver and control of the working day.
- Speed in the dry and rain, providing a reduction in accidents and speeding fines and promoting the practice of defensive driving.
- Speeding violations with precision (direct from the speedometer) and support of audible warnings to drivers.
- Control of the economic range of RPM and speed, providing fuel savings and increasing the interval between corrective maintenance, in addition to reducing maintenance costs due to poor driving.
- Drivers' performance through ranking.
- Time of use of the vehicle in "toothless".
- Braking and sudden start.
- Improper clutch usage time.
- Real control of hours worked. Functionality widely used in machines or equipment that work at a standstill, such as compressors, generators, containers, cranes and munck trucks, among other machines at the customer's discretion.
- Special speed. This event log indicates speeding on an embedded fence, predetermined by the user.
- Arrival Notice. Through the boarding of points, the system identifies when the vehicle is close to the company, helping all yard logistics.
- ASO control. The system sends notices by e-mail 15 (fifteen) days before the exam is due.
- Control of National Driver's License (CNH). The system sends notices by e-mail 15 (fifteen) days before the expiration of the driver's license.
- Checkpoints and embarked fences. This functionality supports companies in quickly identifying the location of the vehicle when it is at work (for example: gas station, customer A, customer B, residence of employee A, etc.).

Figure 5

Trajectory and details of the trip



Source: Google Maps, APP Mix/M2M (2022).

Telemetry also allows the elaboration of the ranking of drivers based on the analysis of the information on how they drive the vehicles, identifying those that are above or below the average values calculated, making it possible to establish measures that corroborate the better performance of these professionals and, consequently, a better use of the vehicles, resulting in lower operating and maintenance costs (Figure 5).

4.3 THE PRESENCE OF INNOVATION IN THE TIJUQUINHA GARAGE

Since its foundation, Tijuquinha has sought innovation incessantly. The company was one of the first to make use of indoor and outdoor filming technology, which began to be used in 1995, being mandatory in the sector only in 1999; also regarding the use of GPS for better distribution of vehicles along the lines, which happened in 2004, being the standard technology for the sector only in 2009.

It could not be different in the implementation of telemetry. Tijuquinha is the first in the world to implement this technology in articulated buses. The first attempt began in 2017, being successful in 2018. It will be nothing new if this technology becomes the standard for the industry in the coming years.

Telemetry imposes several challenges, including the need for a qualified team to treat the huge database that technology offers, so that they can be aggregated and transformed into useful information that enables the breaking of paradigms.

The main justifications for continuous innovation in the company are to increase its market share and improve the return on investment of its shareholders.

4.4 COST AND TIME FOR IMPLEMENTATION

The installation of the equipment is simple. The implementation time is one week, and the validation tests last at least three months. The company Auto Viação Tijuca S.A. finished the validation phase in May 2018.

Equipment was installed in 10 (ten) cars. Each vehicle has its equipment, and each driver has a unique key that links it to the vehicle at the time of operation. Maintenance has keys to perform the necessary tests, which allow the identification of the last professional who operated the vehicle.

The biggest difficulty in the testing phase was the engagement of the drivers themselves. But the transparency in the dissemination of the results made the advantages of the project discovered, and so the engagement occurred gradually.

During the validation period, at no cost, the equipment was loaned. After the signing of the commercial agreement, the equipment was implemented in the entire Tijuquinha/Normandy fleet.

The price of a telemetry service is between R$ 140.00 to R$ 200.00 per monitored vehicle.

4.4.1 Expected Results

- Evolution in management and control.
- Reduction of overtime and labor liabilities.
- Standardization of the way vehicles are driven.
- Development of driver awareness and training policies.
- Increased vehicle life, with the consequent reduction in vehicle downtime.
- Reduction in fuel consumption.
- Reduction in the number of fines.
- Reduction in the number of claims.
- Reduction of polluting gases.

4.5 THE BENEFITS

4.5.1 For Customers

Customers directly benefit from the telemetry system, as it monitors speeding, improper use of the brake, sharp curves, among other drivability events that can be used to monitor and guide the training of drivers in driving vehicles.

4.5.2 For managers

The main benefit for managers is to monitor, through remote control of the fleet, the management KPI's, in which the performance of drivers in relation to the goals established by the company is verified.

4.5.3 For entrepreneurs

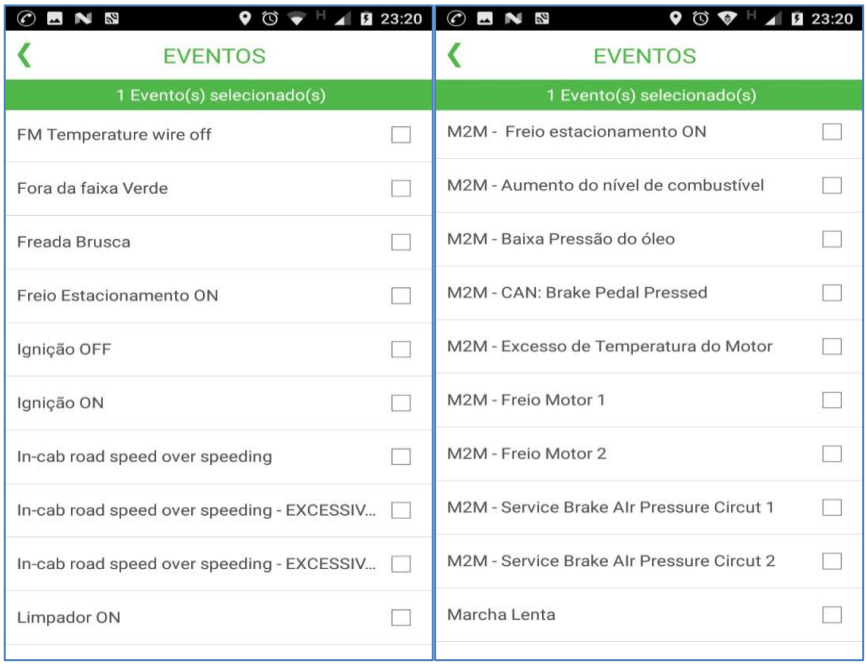
The first benefit is in the reduction of costs. But it is not limited to this, as telemetry naturally brings a culture of meritocracy to all areas of the company.

4.6 THE RESULTS

The results are surprising, for example, the ease of remotely turning off the vehicle that is idling for a predetermined time of 10 minutes. It is very common for the driver to leave the vehicle on and leave it for various reasons, so when this occurs, the vehicle is turned off remotely, reducing its wear and tear and fuel consumption. Figure 6 lists some of the events that can be monitored by the smartphone app.

Figure 6

Events that can be selected to be followed



Source: Google Maps, APP Mix/M2M (2022).

4.6.1 Reduction of accidents and fines

With telemetry, the entire road was mapped, and the driver is informed in advance of radars and stations. This reduced fines and accidents.

There was a 5% reduction in all types of accidents, in addition to a reduction in their severity. As for fines, there was a significant reduction of 98%.

4.6.2 Fuel and CO2 emission reduction

Drivers started to operate the vehicle correctly, within the green range (extra-economic range), thus reducing fuel consumption by 15% and, consequently, releasing less CO2 into the atmosphere.

4.6.3 Reduction in tire consumption

A better operation of the vehicle, with a reduction in sudden braking and greater use of the retarder brake to the detriment of the service brake, provided less heating of the wheels. Consequently, tires are saved more, promoting an increase of up to 5% in their useful life.

4.6.4 Less corrective maintenance

As the operation is done correctly and monitored, the tendency is for there to be less corrective maintenance. For example: wheel heating, coolant heating, pneumatic bellows displacement, etc.

4.6.5 Increase in average speed with less time inside the bus

With telemetry, you can monitor the downtime, which increases the average speed. Consequently, the customer will spend less time inside the bus.

4.7 THE CURRENT DIFFICULTIES IN CONTROLLING VEHICLE DATA IN REAL TIME

Currently, it is possible to monitor vehicles to:

- geolocation of vehicles (individual or group);
- address and date of each location;
- monitoring of events;
- distance traveled;
- speeding;
- custom reports;
- configuration of alerts;
- fences and virtual fines.

However, in the case of BRT, vehicles circulate in segregated lanes, with an independent system for applying fines and with entry and exit of passengers in their own (elevated) stations.

Thus, although the lanes are segregated, there are several intersections with the ordinary lanes, and with telemetry it is possible to check the places with the highest occurrence of events or accidents, especially in case of weather changes, to quickly warn the driver about the adversities that lie ahead.

The use of telemetry has already allowed the saving of fuel, rolling stock, shortened the maintenance time of vehicles, increased safety in transport and, above all, reduced the emission of polluting material.

5 FINAL CONSIDERATIONS

From our objective to demonstrate the importance of the search for innovative initiatives as a critical success factor for urban mobility companies and the benefits of implementing telemetry in the BRT/RJ modal, as well as the changes that the introduction of

a new technology can bring to the business model and how decisive the human factor is as a transforming agent, We seek to describe the process of implementing telemetry. To this end, we conducted a series of interviews with representatives of Tijuquinha and Normandy, who promoted this innovative initiative, in order to find out how its implementation took place, difficulties, risks and benefits generated.

The innovative initiative presented in this application project enabled the companies Tijuquinha and Normandy to obtain a significant cost reduction associated with improved quality, especially in vehicle driving, which was clearly perceived by their customers. These results established a competitive differential and allowed the companies to continue operating, despite the difficulties imposed by the economic crisis that we describe in this work.

The benefits of extending the innovative solution applied in the Tijuquinha and Normandy partnership to the other companies of the BRT/RJ System in the City of Rio de Janeiro are of paramount importance for the development of urban mobility in the State and even beyond our borders. If this initial one is extended to the other companies that operate BRT buses, there will be a general improvement in the quality of the companies and the system, through a lower number of breakdowns and consequent increase in the availability of vehicles. In this way, compliance with the BRT operator's schedule is guaranteed and, with that, a greater supply of seats, reducing overcrowding. There will also be a reduction in accidents, in addition to greater comfort for customers, with the improvement and standardization of bus driving. We cannot forget the benefits to the environment with the reduction of fuel consumption, CO2 emissions and tire consumption.

For all of us who worked on the preparation of this Project, it was possible to perceive a clear evolution of our knowledge about the challenges of urban mobility in the metropolitan region, its history and evolution, to better understand its current infrastructure, in addition to the impact of the economic crisis on companies. It was also possible to develop our capacity for collective reflection on such a complex topic and of which we are part, influence and are influenced.

As we discussed in our theoretical framework, for Schumpeter (1997), innovation can be understood as the fundamental impulse that initiates and maintains the movement of the capitalist machine, from which arise "new consumer goods, new methods of production or transport, new markets, new forms of industrial organization that the capitalist company creates".

In this line of thought, the innovation presented still has several opportunities for development, and it is essential that there is continuity so that it is possible to explore its full

potential. This search for innovative initiatives should not be limited to Telemetry or be seen only as a technological solution. New technologies offer opportunities for much broader change than simply deploying systems and equipment. The incorporation of new technologies can change business models, introduce new habits and needs that were previously non-existent and that always depend on the human factor to be successful. The impacts of the development and deployment of new technologies on the behavior of people influenced by the change must be carefully managed to ensure the success of projects.

Currently, we have several technological solutions under development that may one day be applied to urban mobility solutions such as BRT. Just to name a few of them, we can list: battery or hybrid vehicles; autonomous vehicles, as already existing in subways in several cities around the world, for example, on Line 4 of the São Paulo Metro; new means of payment, eliminating current methods; new ticketing platforms with the increasing use of smartphones, the internet and its derivatives; applications of big data and artificial intelligence to evaluate demand behavior and define the best operational plan; Big Data and Artificial Intelligence applications for analyzing the operating pattern of assets (buses, trains, planes, escalators, etc.), which identify deviations from these standards and enable a scheduled maintenance action even before failure, increasing the safety, reliability, and availability of assets that are essential in urban mobility systems.

Still as an innovative initiative, it is necessary to continue in the search for solutions that enhance the strengths of each of the modes and companies, enable an integrated operation that meets the needs of the population at an adequate cost and that fulfills its historical role as a driving element for the growth of the City, without, however, making companies unviable. The creation of a Metropolitan Transport Authority, a legal entity endowed with administrative and financial autonomy to organize the issue of transport within the Metropolitan Region of Rio de Janeiro, may be one of the solutions to the urban mobility crisis that we are experiencing in our city. A metropolitan management of urban transport acting in the planning, regulation, coordination of mobility actions and the dissemination of good practices and innovative initiatives can make urban transport companies viable, bringing benefits to companies, government and contributing to the improvement of the quality of life of the population.

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