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TELEMETRY AS AN IOT TOOL IN VEHICLE FLEET SAFETY MANAGEMENT

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ABSTRACT

Telemetry is one of the main Internet of Things (IoT) tools applied to fleet management, allowing geographic tracking, speed measurement, and monitoring of other variables in real time, through wireless communication in remote and urban areas. This study aimed to verify the application of this IoT technology in the safety management of vehicle fleets, exploring its contribution to the reduction of incidents and the increase of operational efficiency. Telemetry technology, with data transmission and continuous monitoring, enables managers to make more assertive decisions about the safety of drivers and employees, in addition to optimizing logistics and reducing costs related to fleet operation. The methodology was based on an exploratory and analytical approach, combining a conceptual review of articles and books with a case study applied to a large mining company located in Minas Gerais, in 2018. The results indicated that, after the implementation of the telemetry system, there was a significant reduction in the frequency of speeding and, consequently, in the number of accidents. In addition, it was possible to identify recidivism patterns among drivers, which reinforces the importance of continuous monitoring. It was concluded that telemetry, as an IoT tool, not only contributes to increased safety, but also improves operational efficiency, allowing proactive fleet management and opening opportunities for future research, such as the use of big data for predictive analytics.

Keywords: Telemetry. Security Management. Vehicle Tracking.

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INTRODUCTION

The growing demand for technological innovation presents ongoing challenges, especially in overcoming physical and virtual barriers, made possible by the use of the internet. High-speed data transmission, often supported by artificial intelligence, allows the processing of large volumes of information. When this information is analyzed interactively by people and machines, it makes up the concept of the Internet of Things (IoT). IoT refers to a network of physical objects – "things" – equipped with sensors, software, and other technologies, which make it possible to exchange data with other devices and systems through the Internet. These devices range from common household appliances to sophisticated industrial tools (SORRI, 2022).

In this context, telemetry emerges as one of the main IoT tools, with wide applications in the transportation sector. Its relevance goes beyond data collection; Telemetry decentralizes decision-making, allowing devices to perform autonomous actions based on pre-programmed decisions or through artificial intelligence. Originally developed for the tracking of fixed telephony before World War I, telemetry expanded to areas such as agriculture, meteorology, medicine and transportation, but without the real-time connection between machines (FERRANTE; RODRIGUEZ, 2004). Today, this technology is widely used in the monitoring of electric and autonomous vehicles, as well as in the management of light and heavy fleets (ADLER; PEER; SINOZIC, 2018).

For companies, the search for real-time information is vital to carry out transport management in an assertive and safe way. Telemetry provides critical operational data to minimize risk and increase safety in transportation. It allows real-time vehicle monitoring, providing accurate data on the location, speed, and operating conditions of vehicles, which directly contributes to the reduction of operational risks and the prevention of accidents. In addition, in cargo transportation, telemetry facilitates the control of logistics operations, such as displacement, loading and unloading, generating value for customers through greater reliability, safety and reduced delivery time (BOWERSOX, 2006). The public sector can also benefit from the technology, applying it in urban traffic management to avoid congestion and optimize cargo vehicle routes (ADLER; PEER; SINOZIC, 2018).

The relevance of telemetry in safety management is pertinent for both the private and public sectors, especially in the prevention of road accidents. The combination of human failures, such as recklessness and speeding, with mechanical problems, often results in accidents with serious consequences. These accidents not only generate human

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and material losses, but also directly affect the productivity of companies, increasing costs with maintenance, employee health, insurance and vehicle replacement (RUSSO; COMI, 2020). In this way, the implementation of telemetry as a central IoT tool can contribute significantly to increasing safety in transport operations, mitigating risks and promoting greater efficiency.

In addition to the direct benefits to safety, telemetry also allows the optimization of operating costs, which makes its application even more attractive to companies. The ability to monitor the behavior of vehicles and drivers in real time allows for the early identification of risky driving patterns, mechanical failures, and adverse road conditions, enabling the adoption of immediate corrective measures. This reduces vehicle downtime and costs associated with unplanned maintenance, while increasing the lifespan of equipment. In addition, by promoting a culture of safety, telemetry also helps in compliance with safety standards and regulations, avoiding fines, legal actions, and damage to the company's reputation. Telemetry goes beyond accident prevention, generating a direct impact on the financial and operational sustainability of transport companies, which reinforces its relevance in the current context of strategic management (FERRANTE; RODRIGUEZ, 2004).

Given the relevance of IoT implementation and its contributions to safety, this study aims to analyze how vehicle management by telemetry can contribute to safety in passenger transport, based on records of speed incidences. The study sought to verify whether the implementation of telemetry is effective in reducing accidents by allowing real-time monitoring of the speeds practiced by drivers, with the implementation of mitigating actions to curb excesses. The empirical field of this study involves a large company in the mining sector located in Congonhas do Campo, Minas Gerais.

The study has its structure divided into five sessions. The first would find the introduction to the subject. The second found the theoretical framework that guided the methodology. Third, the methodology that the study used to achieve the objective. The fourth session is about the results and the discussion. In fifth and finally, there is the conclusion.

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THEORETICAL FOUNDATION

The theoretical framework was divided into two parts. The first part presents telemetry technology for vehicle tracking. The second part presents the introduction of telemetry technology in the Brazilian context.

TELEMETRY TECHNOLOGY FOR VEHICLE TRACKING

Telemetry technology was initially developed for geographic positioning purposes, being an application that enables the accurate identification of physical objects around the globe. This technology is based on communication by radio waves, using the Global System for Mobile Communications (GSM), establishing a bridge between the tracked object and satellites located in the exosphere. Real-time data transmission allows object positioning to be mapped and monitored with high precision (DRAGO; DISPERATI, 1996). This technological advance has revolutionized several industries, with the transportation sector being one of the main beneficiaries.

Telemetry, according to Drago and Disperati (1996), can be divided into two fundamental processes: hardware and software. The hardware involves the devices installed in vehicles, responsible for capturing and storing operational information, such as speed, distance traveled, and location. The software, on the other hand, interprets this data and provides a user-friendly and customizable interface, allowing managers to analyze the information in real time and make decisions based on concrete data. This technological infrastructure allows not only the monitoring of vehicle behavior, but also the identification of anomalies and risk trends, directly contributing to the prevention of accidents and the optimization of safety.

Regarding the economic impact, Beal (2001) argues that the application of telemetry in the logistics management of transportation results in a significant reduction in operating costs. Telemetry allows for efficient vehicle routing, continuous monitoring of deliveries, and monitoring of vehicle condition, enabling preventive management. This not only decreases maintenance costs and cargo theft, but also increases customer satisfaction by ensuring faster and safer delivery. Bowersox et al. (2007) also highlight that telemetry plays a strategic role in integrating logistical and operational data, allowing a more effective control of the supply chain and reducing inventory levels, which adds competitive value to operations.

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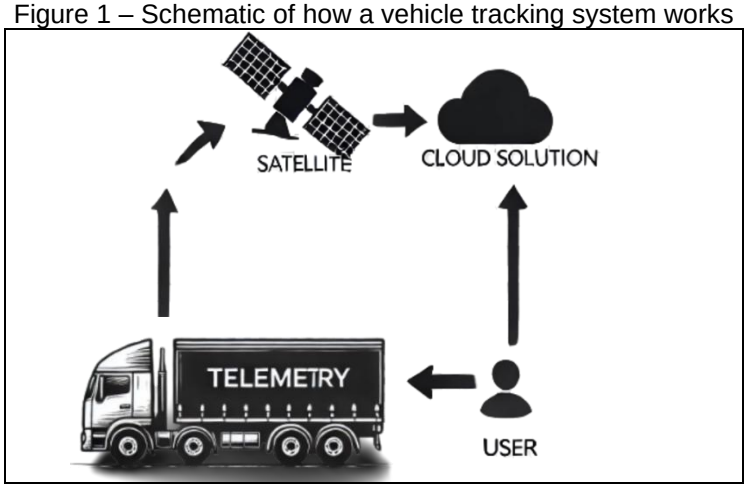
Figure 1 – Schematic of how a vehicle tracking system works



Source: Prepared by the author, 2024

Ferrante and Rodrigues (2004) reinforce that vehicle tracking not only increases the level of service, but also improves operational performance by providing greater reliability and transparency in transportation. In addition, telemetry acts directly on safety, by positively influencing the behavior of drivers, who start to adopt safer practices. Constant monitoring of drivers' actions promotes a significant behavioral change, with the reduction of unsafe habits, such as speeding and sudden braking. According to studies by Russo and Comi (2020), this behavioral change, induced by technology, directly contributes to the reduction of accidents and raises the general level of safety in vehicular transport.

Hoffmann and González (2003) suggest that the continuous monitoring of vehicles generates a behavioral effect on drivers, who tend to adapt to the safety standards imposed by the company. This adjustment is not just technical, but psychological, as drivers internalize safety standards and avoid risky behaviors such as speeding. In addition, the data collected by telemetry provides a source of information for preventive management, allowing companies to implement stricter security policies and intervene directly when unsafe patterns are detected.

The importance of telemetry for transport safety goes beyond basic speed and location monitoring. According to Nespoli (2012), more advanced telemetry systems can monitor other operational parameters, such as the use of seat belts, fuel level, and even adverse weather conditions, such as driving in the rain. This data offers a complete view of vehicle and driver behavior, allowing companies to take proactive steps to mitigate risk. For example, vehicles equipped with telemetry can send real-time alerts to managers if they detect risky behavior, such as sudden braking or route deviations, enabling immediate and effective interventions.

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TELEMETRY APPLIED TO BRAZILIAN TRANSPORT

In the last 20 years, Brazil has made large financial investments in the expansion and revitalization of roads, seeking to improve transport infrastructure. However, the country still stands out negatively among the world leaders in the number of traffic accidents. As Lopes (2012) observes, many of these accidents are not properly recorded, which contributes to the underreporting and underestimation of official statistics. This critical scenario is explained by the combination of factors such as the rapid expansion of the low-quality road network, the lack of adequate signage, the recklessness of drivers, and the accelerated increase in the number of vehicles on the streets, as well as the growth of transport by apps and deliveries of goods (RUSSO & COMI, 2020).

The Brazilian transport matrix is largely dependent on the road mode, representing 62.8% of cargo transport, while rail, waterway, and other modes account for 21%, 12.6%, and 3.65%, respectively (ILOS, 2020). This concentration in road transport increases exposure to the risk of accidents, especially due to poor road conditions and the lack of effective enforcement of traffic rules, such as speed limits and prudent driving. In 2022, Brazil ranked second among the countries with the worst traffic rates, according to the OECD, and third in the number of deaths in road accidents (WHO, 2023).

Telemetry, as a vehicle tracking tool, can mitigate the risks associated with road transport. According to the Quatenus report (2019), the four main causes of deaths in Brazilian traffic – lack of attention by drivers (31%), speeding (22%), alcohol intake (15%) and disobedience to signs (10%) – can be directly addressed through the use of telemetry systems. By monitoring speed, driver behavior, and vehicle conditions in real time, these systems provide managers with essential data for quick and effective interventions, with the aim of preventing accidents and increasing safety.

Studies prove the effectiveness of telemetry in transportation management, by allowing managers to identify patterns of risk behavior and adopt corrective measures. As pointed out by Ogden (1996) and Hutrc (2011), the probability of accidents increases drastically when vehicles exceed the allowed speed limits, and these situations can be mitigated through active management and driver awareness. Telemetry provides a robust platform for these actions by providing real-time alerts on speeding violations, dangerous behavior, and mechanical failures, enabling preventative management.

In addition, the impacts of traffic accidents go beyond the loss of life. As pointed out by Ferraz et al. (2008), accidents cause direct consequences to public health, with victims

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suffering physical and psychological trauma, often resulting in motor disability and early retirement. There are also repercussions on the economy, with the loss of productivity caused by the absence of workers, in addition to the costs associated with indemnities and insurance. According to the CNT (2023), the total cost of accidents with deaths on Brazilian federal highways was estimated at R$ 13 billion in 2022. Therefore, the use of technologies such as telemetry has a significant impact not only on safety, but also on reducing economic and social costs associated with accidents.

The role of telemetry in safety goes beyond basic monitoring, allowing companies and public agencies to identify risk areas and adopt proactive measures to minimize accidents. By providing detailed information about vehicle operation and driver behavior, telemetry becomes an indispensable tool in modernizing fleet management and creating a safer and more efficient transportation environment. The integration of this technology with data analysis algorithms and artificial intelligence further increases its potential, allowing the prediction of risk events and the implementation of high-impact preventive strategies (RUSSO & COMI, 2020).

TELEMETRY AS A TOOL FOR MANAGING PERFORMANCE AND OPERATIONAL EFFICIENCY

Telemetry plays a crucial role not only in safety, but also in managing the performance and operational efficiency of fleets. By monitoring real-time data such as fuel consumption, mileage, idle time, and engine performance, managers can identify operational inefficiencies and implement predictive maintenance and fuel economy solutions. As a result, businesses that utilize telemetry efficiently can optimize the use of their vehicles, reduce maintenance costs, and maximize productivity. Gubbi *et al.* (2013) highlight that IoT, integrated with telemetry, provides a continuous view of operations, which generates insights for operational adjustments that positively impact costs, sustainability, and the reduction of carbon emissions.

In addition to improved efficiency, telemetry allows fleet managers to set higher operational standards. This translates into benefits ranging from the control of vehicle idleness to the reduction in wear and tear of mechanical components, which reduces the need for corrective maintenance and avoids unplanned downtime. Telemetry also contributes to reduced downtime, as potential problems are detected early. By optimizing maintenance and operating costs, companies also contribute to sustainability by reducing

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the environmental impact of their operations. Gubbi *et al.* (2013) argue that the use of IoT technologies such as telemetry is an efficient strategy to promote operational and energy savings.

With the increasing adoption of telemetry in transport fleets, the data generated by these tools can be integrated into big data systems, which increases the ability of companies to predict risky behaviors and prevent accidents. By collecting large volumes of data on driver behavior, road conditions, and vehicle maintenance, it is possible to identify patterns that indicate potential problems. Big data-based predictive analytics allows businesses to take preventative action before incidents happen. According to Manyika *et al.* (2011), the integration between telemetry and big data transforms the way companies manage security, providing a comprehensive view of operations and creating a safer and more efficient transportation environment.

In addition, the use of telemetry and the analysis of driver behavioral data can have a direct impact on reducing insurance costs. Companies that demonstrate tight control over their drivers' behavior, such as enforcing speed limits and adopting safe driving practices, are able to negotiate better insurance contracts. This is because telemetry offers accurate data that proves the adoption of effective safety policies, reducing claims and, consequently, insurance premiums. According to Gartner (2019), companies that adopt telemetry technologies not only increase the safety of their fleets, but also achieve significant reductions in insurance costs, which represents an important competitive advantage in the transportation sector.

RESEARCH METHOD

In this section, the methodological procedures adopted for this study are presented. The research followed a set of systematic and rational activities, as described by Marconi (2007), with the aim of achieving the objectives with greater precision and efficiency. The study addresses the nature of the research, the logic of the investigation, the approach to the problem and the technical procedures used.

Firstly, the nature of this study is characterized as applied research, with the objective of generating knowledge for practical application, focused on the solution of specific problems in the field of vehicle transport safety through telemetry. According to Silva and Menezes (2005), applied research aims to solve concrete issues, and is suitable

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for this study, which explores the use of telemetry technologies in a mining company and its implications for operational safety.

The research logic follows the inductive method, based on empirical observations. Based on specific data provided by a large company in the mining sector, located in Minas Gerais, the analyses seek to generalize the benefits and challenges of implementing telemetry in safety management. According to Gil (2007), the inductive method is appropriate when it is intended to start from particular information in order to obtain broader conclusions applicable to other contexts.

The choice of the case study as the main methodological approach is justified by the fact that, according to Yin (2015), it is particularly effective for studies that seek to explore phenomena within their real contexts, especially when the boundaries between the phenomenon and the context are not clearly delimited. In this study, the use of telemetry in a mining company offers an ideal empirical field for the direct observation of the impacts of this technology on vehicle safety, which makes the case study the most appropriate approach. To ensure the validity and reliability of the data collected, strict quality control measures were adopted, based on reports automatically generated by the telemetry system. As suggested by Flick (2009), the reliability of the data is essential for the credibility of the conclusions obtained. In the present study, the data were validated through cross-checks with the company's internal records, ensuring that the information was accurate and consistent throughout the monitored period

Thirdly, the study adopts a qualitative approach, which, according to Moresi (2003), is appropriate when there is a dynamic relationship between variables, as is the case of security and telemetry management. The qualitative research aims to explore this relationship in a descriptive way, seeking to describe and understand the impacts of tracking technologies on fleet management and driver safety.

As for the technical procedures, the study is based on a literature review and a case study. The literature review was carried out to consolidate concepts and theories about telemetry and safety management, as suggested by Lakatos and Marconi (2007). The case study was conducted in a mining company, whose telemetry system was implemented in 2018, with the aim of reducing speed-related incidents and improving driver safety. The essence of the case study is to clarify the decisions made by the company regarding the implementation of the technology, in addition to investigating the results obtained.

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The data used were provided by the mining company located near the BR-040, south of the municipality of Belo Horizonte. For four months, from May to September 2018, the fleet vehicles were monitored using telemetry. The information collected includes data on speed, driver behavior, and the impact of these variables on vehicle safety. Due to confidentiality agreements, the name of the company will not be revealed.

The publication of the data collected in 2018 in 2024 is justified due to the need to safeguard the operational secrecy of the company studied. The data was kept confidential for a period necessary to ensure the strategic security of sensitive information related to mining operations and fleet management. Only after the complete implementation of the telemetry system and the consolidation of the results was it possible to disclose the data without compromising the company's competitiveness. In addition, the time lag allowed for a more in-depth and mature analysis of the effects of telemetry, offering a long-term view on the benefits and challenges of the technology, which makes the publication in 2024 relevant and timely.

RESULTS

The company under analysis is one of the main players in the mining segment in Brazil, with emphasis on the export of ores and semi-finished products in steel alloys. The transport of these materials is mainly done by rail to the Port of Itaguaí, in Rio de Janeiro. Safety in the transport of light and heavy vehicles, essential for internal operations, has become a priority in the face of operational risks and the history of incidents. The implementation of the telemetry system aimed to address these challenges, especially the recurrence of recklessness in speeding.

Before the adoption of the telemetry system, the recklessness of drivers, especially with regard to speeding, was widely known by management. However, corrective actions were limited to reactive measures, such as lectures and awareness campaigns, which did not have a lasting impact on behaviors. Recurring reports from passengers about speeding abuses indicated a culture of disrespect for the limits imposed by the company, despite the existence of rules that established the limit of 110 km/h on the highways. As presented, studies indicate that the simple imposition of standards, without continuous monitoring mechanisms, is insufficient to mitigate risks, corroborating the need for more robust technological solutions (HOFFMANN & GONZÁLEZ, 2003).

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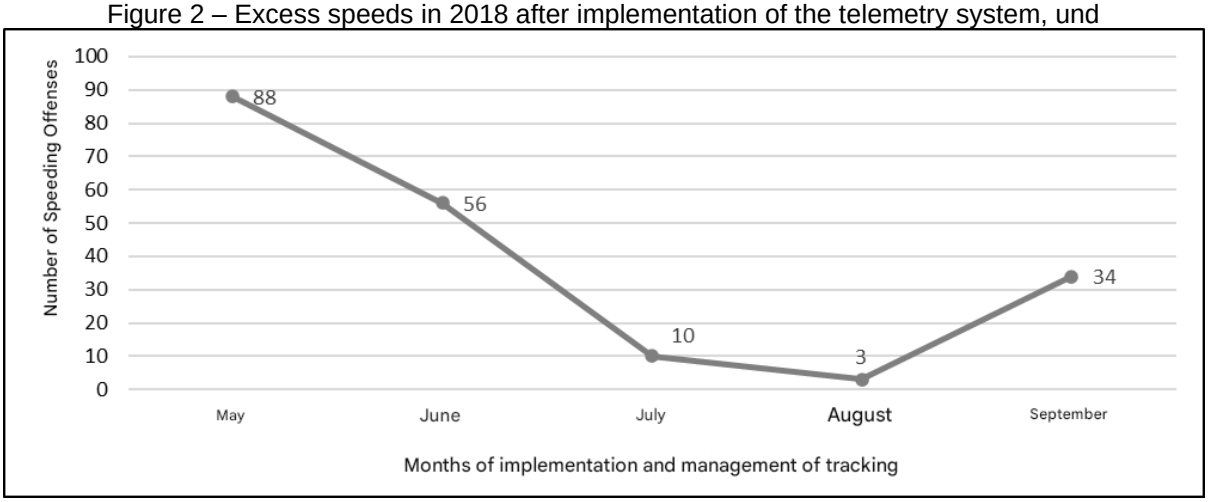
Since the implementation of the telemetry system in May 2018, the vehicles in the fleet have been continuously monitored. The system recorded data such as speed, distance traveled, stops and driver behavior in real time. The identification of drivers before the departure of vehicles ensured greater responsibility for driving behavior, since actions were now directly attributed to specific individuals. This improved control was decisive for the reduction of abuses.

The data collected indicate an average reduction of 48.3% in the frequency of speeding during the monitoring period, see Figure 2. In the months of July and August, the decrease was even more pronounced, reflecting the positive impact of the manager's intervention, which reinforced the awareness of drivers based on the information provided by telemetry. Figure 2 presents a clear visualization of this downward trend in speeding incidents, confirming that the telemetry system not only monitored but also induced behavioral changes.

Figure 2 – Excess speeds in 2018 after implementation of the telemetry system, und



Source: Prepared by the authors

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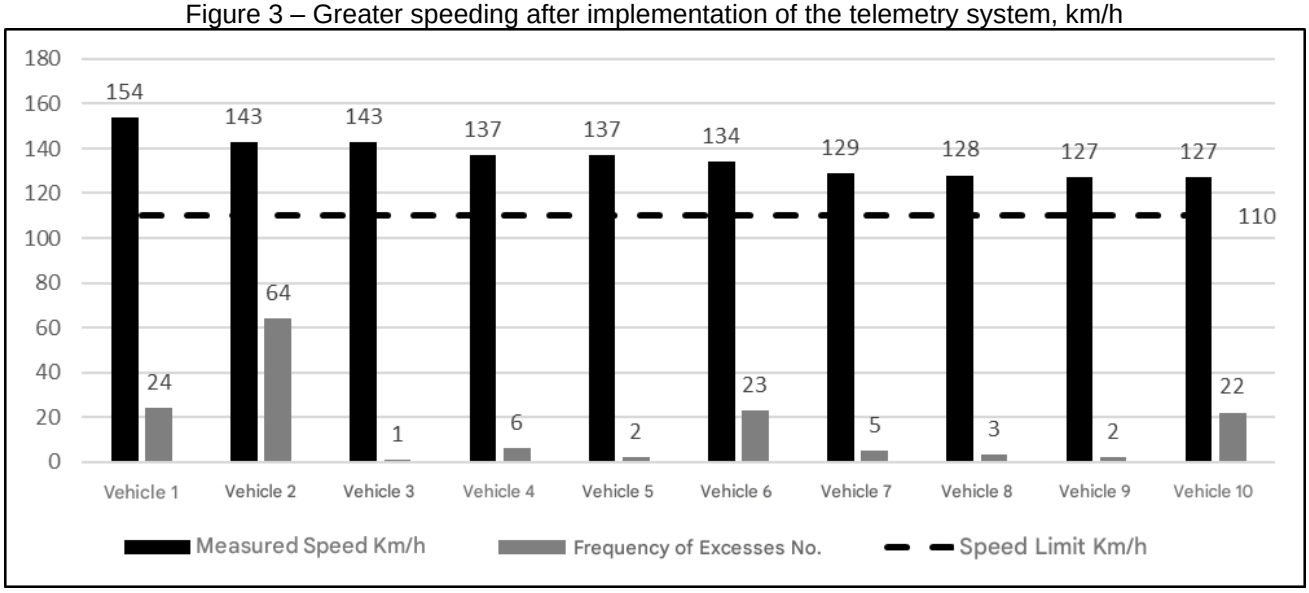
Figure 3 – Greater speeding after implementation of the telemetry system, km/h



Source: Prepared by the authors

The practical impact of this reduction in incidents goes beyond security. The reduction in speeding decreased vehicle wear and tear, which led to a decrease in maintenance costs and increased fleet availability. In addition, the company reported an improvement in the working conditions of drivers and passengers, generating a safer and less stressful transport environment. The decrease in the number of accidents also resulted in a reduction in costs associated with repairs and claims, reinforcing the financial sustainability of the operation.

In September 2018, an increase in the frequency of speeding was observed, due to a technical failure in the vehicle starting system, which allowed drivers to start their cars without prior identification. This incident highlighted the importance of maintaining continuous control and performing regular maintenance on telemetry systems to ensure effective monitoring. The lack of identification of drivers allowed reckless behaviors to occur, validating the studies by Hoffmann and González (2003), who state that, without monitoring, drivers tend to disregard the risks.

This temporary increase in incidents reinforces the need to ensure that monitoring systems are robust and fail-safe. The company quickly corrected the problem, which resulted in a resumption of good driving practices. This episode served as a learning experience for future technological implementations, highlighting the need to anticipate contingencies to maintain active and continuous monitoring.

The telemetry system also provided detailed data on vehicles that exceeded the speed limit established by the internal safety standard, set at 110 km/h. The analysis of the

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data revealed that 10 vehicles stood out for the highest deviation from the limit, with speeds significantly higher than the allowed. Figure 3 illustrates the behavior of these vehicles, highlighting the severity of the infractions.

Vehicle 1 recorded the highest infraction, traveling at 154 km/h, that is, 40% above the established limit. This deviation represents high-risk behavior, potentially increasing the number of accidents and wear and tear on vehicles. According to Hoffmann and González (2003), driving above the speed limits not only increases the risk of serious accidents, but also reduces the driver's ability to respond to unforeseen events on the road. The impact of driving at this speed in a mining operation, where safety is paramount, becomes even more critical given the complex nature and risks associated with this type of transport.

In addition, vehicles 2 and 3 recorded speeds of 143 km/h, approximately 30% above the allowed limit. These deviations are not isolated and reflect a worrying pattern of recidivism among drivers of these vehicles, which reinforces the need for continuous monitoring and immediate corrective actions. The high speeds recorded show the need to review driver training and awareness practices, as well as to reinforce internal safety policies, with a focus on risk mitigation actions.

The analysis of the recurrence of speeding also brought relevant insights for fleet management. Vehicles 2, 6 and 10 stood out as those with the highest number of recurring infractions. Vehicle 2, for example, in addition to having one of the highest speeds recorded, was also the one that recurred the most in violations of speed rules. These data point to the need for a more rigorous intervention, not only in terms of monitoring, but also specific corrective actions for responsible drivers.

DISCUSSION

The results obtained in this study are consistent with the existing literature on the positive impact of telemetry on speed control and safety in vehicular transport. Telemetry has been widely studied as an essential tool for mitigating operational risks and improving performance in vehicle fleets. The 48.3% reduction in speeding incidents, as identified in the analysis, is not only in line with the results of Bowersox et al. (2007), which highlight the effectiveness of telemetry in mitigating reckless behavior, but also reinforces that, when associated with efficient management and corrective actions, this technology can transform the safety culture within companies.

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Another relevant point of the discussion involves the accountability of drivers. The study showed that, after the implementation of the telemetry system, driver identification became a key measure to increase driver responsibility and reduce speeding. Hoffmann and González (2003) argue that continuous supervision, when associated with the clear attribution of responsibility, tends to generate a significant change in the behavior of drivers, promoting safer driving practices. This relationship between monitoring and behavioral change is an aspect that can be explored in more depth in future studies.

The recurrence of infractions, observed in vehicles 2, 6 and 10, highlights another critical point for fleet management. Russo and Comi (2020) suggest that the repetition of unsafe practices, such as speeding, not only increases the risk of accidents, but also has a direct impact on the cost of vehicle maintenance. Telemetry, by providing detailed and continuous data, allows management to act proactively to correct these behaviors. However, the data from the present study suggest that even with real-time monitoring, repeat infractions require a more rigorous approach, such as targeted corrective actions for drivers who exhibit repeated patterns of reckless behavior.

In terms of operational efficiency, reducing speed incidents and increasing safety are not the only benefits provided by telemetry. As noted, the decrease in speeding resulted in a drop in maintenance costs and increased vehicle availability. Studies such as those by Russo and Comi (2020) and Bowersox et al. (2007) already indicate that the reduction of high-risk behaviors, such as speeding, positively impacts fleet performance, reducing the wear and tear of mechanical components and optimizing the useful life of vehicles. Thus, in addition to promoting safety, telemetry generates competitive advantages by reducing operating costs and increasing productivity.

Another relevant point is the impact of telemetry on driver satisfaction. Personalization of telemetry systems, with the emission of audible signals to alert drivers of speeding or unsafe conditions, has played an important role in maintaining focus and attention while driving. This aspect is addressed by Gartner (2019), who highlights that telemetry monitoring systems not only control driver behaviors, but also contribute to a less stressful and safer work environment. The increase in driver satisfaction is also a reflection of a management that uses telemetry data effectively, balancing supervision with the appreciation of safety at work.

In the field of the Internet of Things (IoT), telemetry represents a technology that is constantly evolving. With the increasing integration of big data and artificial intelligence

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systems, telemetry is expanding its boundaries, offering not only real-time monitoring but also the ability to predict failures, optimize routes, and increase operational efficiency in an automated way. This opens up new opportunities for the use of telemetry in the future. For example, Rajkumar et al. (2016) discuss that in autonomous vehicles, telemetry is essential for continuous and safe monitoring, highlighting its central role in future transportation innovations.

These advanced technologies, such as integration with big data, allow companies to use the data collected by telemetry to predict mechanical failures, identify patterns of risky behavior, and thus improve the safety and efficiency of operations. The use of predictive algorithms can help managers make decisions based on detailed analysis of historical data, allowing them to implement corrective measures even before incidents occur. In other words, telemetry is no longer just a reactive tool and becomes a proactive and predictive solution, aligning with automation trends in transportation (Manyika et al., 2011).

CONCLUSIONS

This study achieved its objective by verifying how vehicle management through telemetry contributes significantly to safety in passenger transport, based on speed incidence records. The implementation of telemetry systems, in addition to allowing real-time tracking, promotes a culture of operational safety within organizations, minimizing the risks related to recklessness in traffic. This system reinforces the responsibility of drivers and offers managers a broader and more detailed view of operations, which is essential for strategic and preventive decisions in road transport.

The use of this technology, in synergy with management practices focused on mitigating reckless behavior, such as speeding, not only strengthens road safety, but also contributes to operational efficiency. The possibility of monitoring what happens during driving in real time goes beyond the internal limits of the organization, expanding the ability to identify operational failures and take corrective actions accurately and in a timely manner. In short, telemetry allows the manager to have a more assertive and close control of operational activities, improving the performance and safety of the fleet.

The frontiers of telemetry and the Internet of Things (IoT) are constantly expanding, offering new possibilities for monitoring and managing fleets in an integrated and automated way. With the advancement of IoT, telemetry becomes not just a vehicle monitoring system, but part of an interconnected network that involves smart road infrastructures, autonomous

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vehicles, and predictive analytics algorithms. The continuous development of these technologies paves the way for monitoring to be done at even deeper levels, such as predicting mechanical failures and automating critical decisions, with a direct impact on safety and efficiency. Telemetry, when integrated with broader IoT networks, has the potential to transform logistics operations, making them safer, more sustainable, and more competitive.

For future research, it is suggested to expand the analysis to other variables provided by the telemetry system, such as speed monitoring in adverse weather conditions, analysis of interstices between drivers, and vehicle performance in terms of wear and tear and maintenance needs. These elements can contribute not only to safety, but also to operational competitiveness, by providing valuable data on logistics costs and efficiency. In addition, it would be relevant to investigate the impact of telemetry on fleet management, allocating vehicles and drivers strategically to optimize resources and improve the overall performance of operations.

Another point of discussion is the potential use of big data for predictive analytics in fleets. Integrating telemetry with big data systems can provide detailed insights into behavior patterns and risk trends, allowing companies to act preventively. Applying this data to predictive maintenance and route optimization strategies can further reduce operational costs and increase safety, consolidating telemetry as an essential strategic tool for the transportation industry.

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