# Improvement model to increase the availability of the bus fleet in a personnel transportation company by applying TPM and AI

Alexandra Castro-Panta, Engineer Student[1], Dayana Meza-Barrientos, Engineer Student[2], and Martín Saenz-Moron, Mg. Eng.[3]
[1,2,3] Peruvian University of Applied Sciences, Peru, u202019472@upc.edu.pe, [2]u201917032@upc.edu.pe, pcinmsae@upc.edu.pe

***Abstract*– The article proposes a model to improve the availability of a bus fleet in a personnel transport company. After analyzing a 2023 database, it was determined that only 83% of the bus fleet is available, resulting in a 7% technical gap when compared to the World Class availability standard. This gap has significantly affected the company's total annual revenue, leading to considerable financial losses throughout the year. Unscheduled stoppages have caused interruptions in the fleet's planned activities, further exacerbating the situation and negatively impacting overall operational efficiency. To address this issue, the proposed improvement model incorporates both Total Productive Maintenance (TPM) and Artificial Intelligence (AI) tools. The primary goal of the model is to reduce downtime by tackling the root causes of unplanned stoppages and breakdowns in the fleet. Specifically, the second pillar of TPM, which focuses on improving equipment effectiveness and reducing inefficiencies, will play a central role in the overall improvement strategy. Additionally, AI tools will be utilized for data analysis and simulation, allowing for more accurate decision-making based on predictive insights from operational data. The combination of TPM and AI tools will help increase fleet availability and close the existing technical gap. By implementing this model, the company expects to achieve a significant improvement in operational efficiency, leading to fewer disruptions, reduced financial losses, and better overall performance. The model ultimately aims to restore the fleet's performance to meet higher standards of availability, contributing to greater profitability, smoother operations, and long-term sustainability in the company's transport activities.***

***Keywords—availability, maintenance, TPM, artificial intelligent, transport***

## I. INTRODUCTION

According to Statista [1], in 2023, 56.1% of the global population used public transport at some point. In addition, the World Health Organization (WHO) [2] mentions that the shortage of buses by companies that provide transportation services constitutes a global challenge that affects various aspects. Therefore, the lack of public transportation in urban and rural areas generates traffic congestion, restricts access to basic services and aggravates environmental problems. Likewise, the International Labor Organization (ILO) [3] mentions that this problem requires an investment in fleets and cutting-edge technology, together with comprehensive transportation planning to increase availability and efficiency.

In South America, the country with the best transportation system is Chile, since its fleets and subway lines have the modernity and efficiency to provide optimal service to passengers. [4]. On the other hand, comparing Latin American cities with the large cities of the world reveals that they have an average level because the performance of their transportation system only reaches regular levels and efficient and sustainable services are not yet offered to their population. [5].

According to the Ministry of Transport and Communications (MTC) [6], the problem of bus availability in Peru is a factor that affects the mobility and quality of life of the population. According to recent statistics, around 60% of the country's urban areas experience a chronic lack of buses, which consequently generates an increase in traffic congestion of 40%. In addition, it is important to note that currently, in Lima and Callao, more than 22.3 million trips are made daily in total. [7].

First, authors [8] indicate that the lack of knowledge of the correct time and moment of repair and maintenance of a vehicle results in its inactivity, which impacts on its availability. Second, [9] point out that the application of the Total Productive Maintenance (TPM) tool significantly improves availability levels, since in their research they managed to increase availability by 27.84%. Likewise, [10] confirm that TPM not only analyzes and achieves important results in availability, it also evaluates reliability. Since, they managed to increase availability by 10%. Thirdly, [11] state that fault diagnosis guarantees the safety of operations, therefore, it maintains availability levels, but it is in the implementation of Artificial Intelligence (AI) tools that results are achieved with greater precision and early alerts are generated to manage the determined maintenance. Thus, the availability of the study units is guaranteed. Finally, [12] focused on the study of the components of a mobile unit, they implemented the digital twin model, which refers to a computer system that receives and provides the same information, because, when processing the information, it provides optimal results on fault diagnosis. In this case, results with 100% accuracy were obtained after its application.

The methodology adopted is ideal, since it seeks to reduce downtime and, in turn, increase availability. It also proposes to revolutionize the way in which the bus fleet is managed and maintained, offering a proactive approach that transcends traditional methods. In addition, its efficient application manages to minimize maintenance costs and, above all, significantly reduce the environmental impact. Success stories have shown that Total Productive Maintenance (TPM) and Artificial Intelligence (AI) are excellent tools for improving availability and maintenance management. In addition, they use industrial engineering methodologies and models that facilitate the identification of root causes of the problem. Therefore, it is expected that the techniques to be implemented such as 5S, analysis and simulation systems together with TPM tools and AI application will positively impact the company under investigation.

Finally, a series of steps will be taken to develop the article. First, important data on the problem is reviewed. Next, we identify the solutions that have been previously implemented to address this problem, along with a thorough analysis comparing our reality with the success cases reviewed. Then, we design the proposed model applied to the case study. Finally, we validate the results obtained in order to conclude how successful the model has been.

## II. Literature Review

### A. *Availability*

Availability is a crucial factor in assessing the effectiveness of maintenance management, as it refers to the uptime that equipment has for operation compared to the time in which it is ready to operate. In addition, it is noted that availability is crucial in any operational activity, as it directly influences the organization's ability to achieve its goals. In the field of maintenance, availability is linked to the ability of equipment to operate with 100% reliability [13].

### B. *Total Productive Maintenance*

Total Productive Maintenance (TPM) is a methodology that involves all areas and levels of the company to optimize equipment, eliminating failures and their possible causes [14]. It encourages autonomous maintenance performed by production operators as part of their daily activities, resulting in increased productivity through greater equipment availability and improved quality of services. This methodology is based on eight pillars, from which autonomous and planned maintenance will be developed. In the title of an article, capitalize the first word and all other words, except conjunctions, prepositions with less than seven letters, and prepositional phrases.

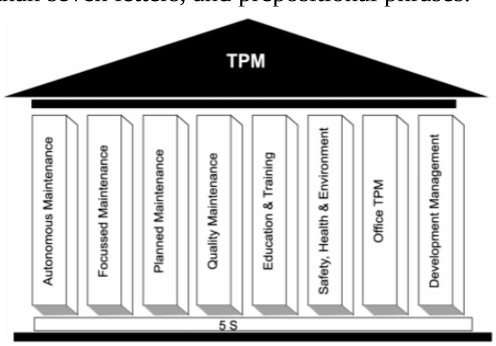


Fig 1. Pillars of TPM.

*Note. From the "Japan Institute of Plant Maintenance", by* Processes, 2023 (https://doi.org/10.3390/pr11071956).

### C. *Artificial Intelligence and Digital Twins*

According to [15], Artificial Intelligence (AI) has revolutionized numerous sectors by providing advanced tools for data analysis, event prediction, and automation of complex processes. Among its most promising innovations are digital twins, [16] accurate virtual representations of physical systems that allow monitoring, simulating, and optimizing their operation in real time. These digital twins, enabled by AI, offer a deep understanding of the behavior and performance of systems, facilitating early fault detection, the implementation of predictive maintenance, and the continuous improvement of operational efficiency. This is confirmed by [17], as they point out that a digital twin is a virtual model of a physical system that constantly updates data on the performance, maintenance, and overall health of the physical system throughout its lifetime. In the context of transportation, the integration of digital twins with AI can transform fleet management, significantly reducing electrical failures and improving bus availability.

### F. *Inventory management*

Inventory management, according to [18] the efficient administration of the inputs and outputs of products stored in a company. In any business, this management is essential to control the investment in relation to the stored value and its rotation. Performing inventories is vital to verify the accuracy of the records in the database or system used. This management is crucial to prevent financial problems, since inventory is a current asset that, although it has low liquidity, contributes to financial success by providing profitability.

## III. Contribution

### A. *Basis*

After carrying out a thorough literature review in the introductory chapter, it can be concluded that the personnel transport sector plays a fundamental role, not only at a regional level, but with greater importance at a global level within the service industry. This is due to its significant contributions in terms of efficient and safe mobilization of workers, making it an essential component of the global economic landscape.

Taking these factors into account, it is imperative to focus on formulating a proposal that would effectively address the identified problem: the low availability of the bus fleet. By addressing this situation, either by eliminating the problem or by reducing the frequency of these interruptions, a positive change would be achieved on a large scale, benefiting not only the company, but also other companies in the personnel transport sector, thus generating a significant impact.

### B. *Proposed Model*

A solution model is proposed designed to increase the availability of the bus fleet, which includes both inputs and outputs, and is composed of two main elements. The first component is oriented towards maintenance management, through the adoption of two pillars of Total Productive Maintenance (TPM). The second component focuses on optimization and safety, incorporating the use of Artificial Intelligence (AI) together with inventory management.

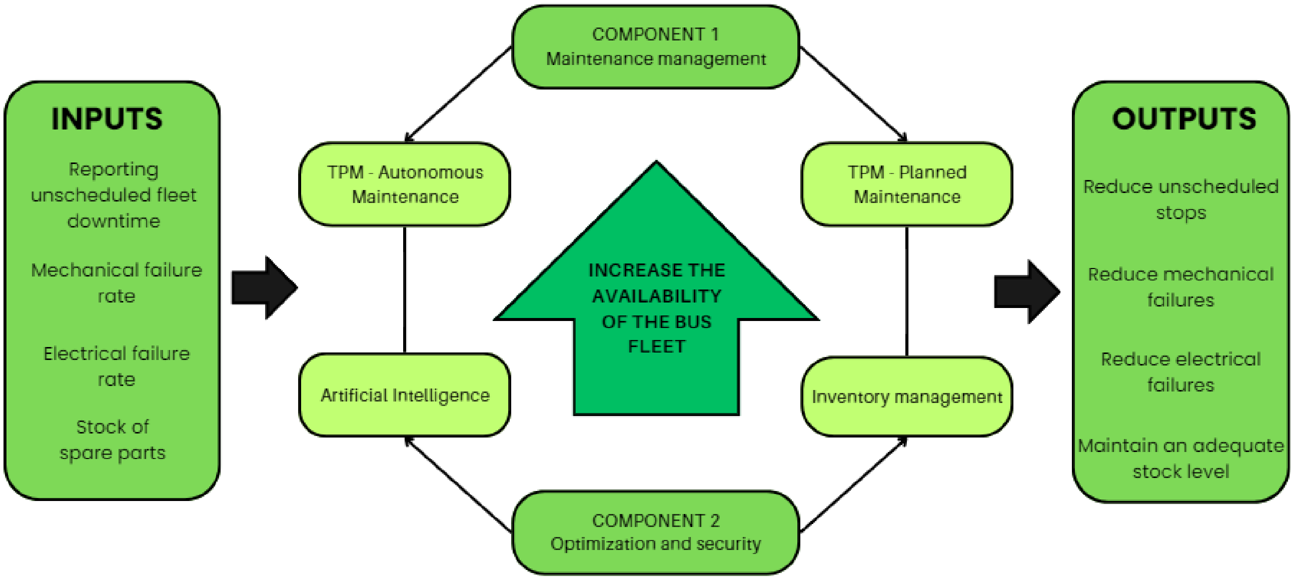


Fig 2. Proposed Model

C. *Proposed Model*

**Component 1:** Maintenance Management

The first component concerns maintenance management, which aims to ensure the availability and reliability of vehicles for efficient and effective operation of the organization. This involves reducing downtime and improving vehicle effectiveness. To achieve this, autonomous maintenance and planned maintenance will be used. Autonomous maintenance aims to involve the operators responsible for the vehicles, leading to greater efficiency, fewer failures, and a better understanding of vehicle operation and safety [19]. Planned maintenance, on the other hand, seeks to reduce sudden failures, optimize resources, and improve operational efficiency through proactive maintenance management [20].

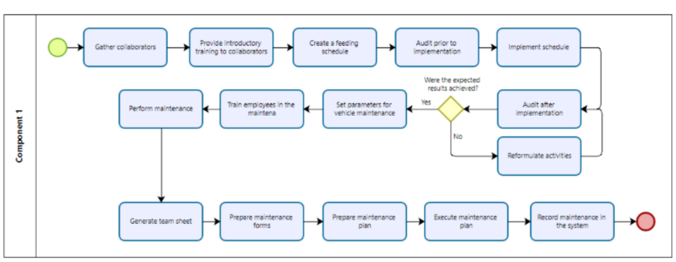


Fig 3. Flowchart of component 1.

Autonomous maintenance begins with training drivers and operators to identify anomalies and perform necessary maintenance such as "Ref. [14]". Training sessions will cover autonomous inspections, basic maintenance techniques, and early fault detection. In addition, specific manuals and guides will be provided for each bus system, such as the hydraulic, drive, brake, and filter systems, among others.

Drivers will be provided with checklists to ensure that each unit they service is in good condition. These inspections will be divided by system type, and the driver will record and comment on the observations at each point to hand them over to the maintenance area. This will allow the condition of the unit to be monitored. The maintenance area will then collect these documents to keep a monthly record of the failures that have occurred and thus identify patterns and trends in failures over time. This record will allow for strategic planning of maintenance, making improvements and adjustments based on the data collected. In addition, a maintenance record will be implemented detailing the maintenance performed, the personnel involved, and the autonomous activities carried out.

Planned maintenance will focus on creating a preventive maintenance plan to avoid unscheduled bus stops such as in "Ref. [20]". First, an analysis of the recorded failures will be performed to prioritize critical points and establish appropriate maintenance intervals. Based on this analysis, specific parameters will be established for each type of system, including the hydraulic, drive, transmission, shock absorbers, brakes, filters and tires, with specific mileage ranges for each maintenance task. Once the parameters are defined, the person in charge of the maintenance area will inform the staff about the mileage monitoring of each unit so that the maintenance plan is carried out according to the established parameters. Finally, the use of a Kanban board will be implemented, where labels will be placed indicating the type of maintenance that corresponds to each unit and its status (scheduled, in process or performed). To correctly implement both pillars, it is essential that employees are properly trained and rigorously follow the defined activities within the established time.

**Component 2:** Optimization and security

The second component addresses the implementation of Artificial Intelligence (AI) for the detection of electrical faults and the inventory management tool will be implemented in order to ensure adequate levels of spare parts stock [21] and thus increase the availability of the bus fleet. The integration of AI allows the development of virtual models of the electrical systems of the buses, through the implementation of digital twins that integrate real-time data from sensors and diagnostic systems [22]. In addition, inventory management facilitates more efficient and precise planning, optimizing resources and guaranteeing the availability of the necessary spare parts. For this purpose, a management system such as SAP Inventory Management will be used, which will allow optimizing inventories and ensuring the availability of spare parts at the right time and place.

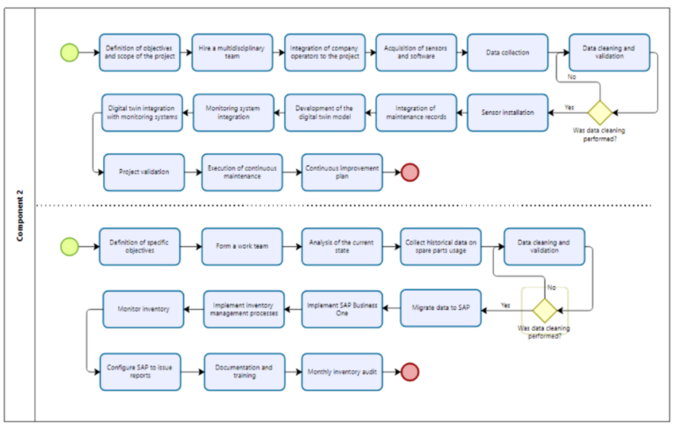

Fig 4. Flowchart of component 2.

For the first part of the second component, which refers to the implementation of digital twins, it will be necessary to follow a sequence of activities to achieve what is established. To start, the project proposal format must be completed, where the scope and objectives will be defined, the hiring of the multidisciplinary team and the integration of operators to the project. Likewise, sensors of various characteristics must be acquired. In addition, data must be collected from the vehicles such as maintenance history, failures, among others. Then, the sensors must be installed and the maintenance records of the units integrated. Continuing with what was mentioned above, the digital twin model will be developed, which will begin with the creation of a detailed model of the electrical systems as in “Ref. [15]”, the critical components will be included, and the digital twin will be configured to replicate the conditions. Likewise, different scenarios will be simulated, and the model will be validated. Once the digital twin is completed, monitoring systems will be integrated and, to do so, connectivity and data transmission must be ensured. Then, the already adjusted digital twin will be implemented and then the validation will be carried out. However, ongoing maintenance and updating of the sensors will be required. Finally, continuous improvement will be assessed, where the project will be measured by results.

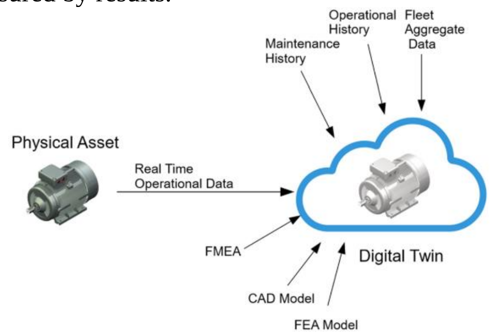


Fig 5. Relationship between the physical and systematic components of digital twins.
*Note.* From “Sustainability” by (Rahmani et al., 2024)

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For the second part of the second component, which implements SAP Business One in inventory management, the specific objectives in inventory management, the work team, the analysis of the status and the collection of detailed data on all spare parts must first be defined. Then, the creation of SAP transactions such as Material Masters, definition of Suppliers and Purchase Data and configuration of Stock Levels must be started. Likewise, processes will be implemented in Inventory Management for greater control over spare parts. The next action will use SAP Business Warehouse for report configuration. However, staff will be trained on the use of SAP Business One. Finally, external audits will be performed monthly to maintain adequate inventory control.

A comparative table of the indicators and the results expected to be achieved will then be established.

TABLE I
EXPECTED RESULTS FOR EACH INDICATOR

| ***N°*** | ***Indicator*** | ***As Is*** | ***To Be*** |
|---|---|---|---|
| 1 | Availability | 83.00% | 90% |
| 2 | Mechanical failure rate | 37.00% | 25% |
| 3 | Electrical failure rate | 12.00% | 5% |
| 4 | Safety stock | 20.00% | 36% |

## IV. VALIDATION

The validation method proposed in this research project consists of using simulation software to demonstrate the behavior of tools in maintenance management.

### A. *Basis*

To support the validation of our bus fleet availability improvement project using Total Productive Maintenance (TPM) and Artificial Intelligence (AI) tools, we will adopt a rigorous and structured methodology based on simulations with Arena software. We will start by establishing SMART objectives (specific, measurable, achievable, relevant and time-bound) to evaluate the effectiveness of the simulation. We will document current procedures in detail, identifying critical areas for improvement. We will define the relevant entities, attributes and activities, considering the interrelations and critical variables that affect system performance. We will use graphical tools such as flowcharts to visualize the relationships and facilitate understanding of the model. We will collect accurate and relevant data, transforming it into an executable model that faithfully reflects the behavior of the real system. We will validate and adjust the model with historical data, if available, and finally analyze and compare the results with reference data to evaluate the sensitivity of the model and verify the achievement of the optimization and downtime reduction objectives.

## V. Conclusions

After analyzing the articles with similar scenarios, the studies of [23][24] used simulators employing the TPM methodology, achieving satisfactory results. In the first case, availability was increased by 27.84%, and in the second case, availability was increased by 5%.

Similarly, in “Ref. [11]” they developed a simulation of the Condition-Based Maintenance App (CBM App) using a digital twin for monitoring and predicting bearing failures. Obtaining the best percentage results, as they included a 100% accuracy in detecting damaged bearings, a 100% specificity, and an overall accuracy of 31.35%.

Finally, [25] developed a plan for inventory management, where they carried out data analysis, financial statement study, inventory record sheets and validation by experts. Obtaining positive results in inventory management with a 7% increase. That is, it was possible to optimize inventory levels and reduce losses associated with the lack of spare parts.

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