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Research Article

Driving Operational Reliability through Lean-TPM Synergy: A Case Study in a Freight SME from Peru

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Abstract: *This study explored recurring operational issues in a medium-sized freight company in Peru, where truck downtime and unplanned maintenance disrupted service continuity. While past research has addressed Lean Manufacturing and TPM separately, few works have brought them together in a way that suits small and medium enterprises. The research developed and tested a hands-on model that combined 5S, Kanban, and autonomous and preventive maintenance strategies to bridge this gap. After applying the model, corrective maintenance hours dropped by nearly 59%, availability improved to 92.24%, and financial losses linked to downtime were considerably reduced. These outcomes suggest that well-structured but simple actions, when adjusted to the company's reality, can lead to tangible improvements and stronger maintenance habits. The results add practical insight to the academic discussion on integrated approaches and offer useful guidance for companies operating under resource limitations. This work encourages future studies on sustainable, tech-supported maintenance models for logistics SMEs.*

Keywords: *Lean Maintenance, Total Productive Maintenance, Fleet Availability, Freight Transport SME, Operational Improvement.*

I. INTRODUCTION

The logistics movement of goods and services provides great economic importance and relevance to every country including Latin America and Peru. In Latin America, Small And Medium Enterprises (SMEs) account for over 90% of businesses and provide numerous job and economic opportunities. Enhanced productivity and efficiency attributed to SMEs is largely due to the increase in logistical demand [1]. Furthermore, logistics and transportation have a competitive focus for growth as almost 50% of cargo is handled by SMEs Peruvian businesses [2]. The rise in employment offers economic prospects that can bolster the efficiency of systems designed to fulfill SMEs and service client demand [3]. Along with competing internationally, these businesses also improve regional development as infrastructure is constructed to suit their sophisticated technological requirements.

Logistics is an essential sector in every economy and plays a vital role in organization movement. However, fleet downtime issues due to operational maintenance schedules can significantly hamper productivity. Studies have suggested that 30% of vehicles could be inactive during operational peak times [4]. Servicing gaps and unstructured servicing amplified by poor maintenance strategies result in a risk of customer servicing and nonfulfillment of quality standards. Costs directly correlated to the increased client order systems reduce client satisfaction standards that impact competitiveness and productivity [6].

Enhancing the fleet's operational readiness is vital for these companies' sustained competitiveness. Adopting Lean Manufacturing and Total Productive Maintenance (TPM) aids in enhancing fleet preparedness and improving operational efficiency [7]. Organizations that implement Total Productive Maintenance (TPM) routinely experience an improvement in fleet availability by 10% to 20% [8], enhancing customer service and bolstering brand loyalty [9].

Even so, there's little research on how Lean tools—like 5S and Kanban—can be combined with TPM techniques, such as Autonomous and Preventive Maintenance, to create a more integrated system. Most studies treat these approaches separately without exploring how they might work better [10]. This study proposes a new model that blends these tools and looks at how to apply them in real-world settings, particularly within Peruvian cargo SMEs [11]. The goal is to offer not just technical improvements but a practical guide for creating a culture of proactive maintenance that can be used by similar companies in the industry [12].

Overall, understanding the links between maintenance issues, fleet readiness, and modern improvement methods is key to helping SMEs in freight transport succeed. This research aims to close a clear gap in the literature and offer practical steps companies can take to improve performance and remain competitive. As logistics becomes more central to business success, investing in maintenance practices is no longer optional—it's essential for any company aiming to stay in the game [13].

II. LITERATURE REVIEW

This research began with a systematic literature review of studies published over the past five years. The aim was to identify existing knowledge gaps and pinpoint the most relevant tools for the study. Based on these findings, an innovative maintenance management model was developed, integrating Lean and TPM tools within the case study context.

A) Lean Manufacturing in Maintenance for Transport SMEs

Adopting better maintenance methods is essential to ensure operational efficiency in the transport sector, as it faces several challenges. Lean Manufacturing is especially useful to Small And Medium Enterprises (SMEs) in the freight and cargo sectors. This approach's core benefit is waste elimination and process refinement, which optimistically translates to improved fleet maintenance. Research underscores that Lean benefits SMEs by minimizing downtimes with Value Stream Mapping (VSM) and continuous improvement processes known as Kaizen [14].

Moreover, there is empirical evidence regarding applying Lean concepts in maintenance systems. For example, some studies carried out in manufacturing companies showed that applying Lean to maintenance operations improved operational efficiency and optimized recovery time objectives [15]. Through cross-training, where employees from different functions are trained to perform multiple roles, SMEs foster a broad culture of incrementalism as unit-based teams toward achieving maintenance, quality, and productivity goals [16]. This is crucial for optimizing logistics and costs, which enhance competitiveness in the transport sector [17].

Strategically, one can monitor the application of Lean maintenance using Key Performance Indicators (KPIs). SMEs with implemented KPIs have realized increased profits and customer satisfaction due to improved fleet availability and reduced delivery times [18]. Also, research studies focus on the contribution of management to the cultivation of a Lean culture, which, nearly always, ensures the success of these enterprises' efforts [18].

In summary, Lean Manufacturing offers an optimal solution to the maintenance system enhancement problem for SMEs operating in the cargo transport sector. Focusing on waste elimination, measuring, and teaching enables these firms to become more efficient and enhance their market competitiveness [14].

B) Using the 5S Method in Transport SMEs

The 5S approach has captured attention as an efficient technique to improve the operational efficiency of cargo transport SMEs. 5S is an acronym of five Japanese words: Seiri (Sorting), Seiton (Arranging), Seiso (Cleaning), Seiketsu (Standardizing), and Shitsuke (Sustaining) [19]. Effective execution of these steps can lead to better order within the workplace, lower maintenance time, and reduced employee attrition.

In a maintenance circumstance, 5S helps SMEs in the upkeep of their tools and machines maintenance, which minimizes unexpected hindrances. One research indicated that using this technique resulted in an overall workspace management improvement within companies, which enhanced behavioural, motivational, and productivity levels in the workplace [14]. Moreover, 5S implementation enhances customer satisfaction directly by improving organizational effectiveness in the logistics processes [16].

As some other studies suggest, 5S facilitates faster identification of disruption in work processes and prompt resolution of the same. This is especially useful in transport, where there may be considerable financial consequences due to delays [18]. In addition, long-term benefits are achieved because employees attend the training sessions offered under the 5S scheme, improving engagement with the work. [16].

To summarize, 5S is an effective answer to the problem of operational and maintenance performance improvement for SMEs involved in freight transport. Better structured workspaces improve operational efficiency and responsiveness to market needs [18].

C) Managing Spare Parts with Kanban

Freight transport SMEs need an efficient spare parts system so that maintenance is done in a timely manner, ensuring their assets are optimally operational. Kanban is a useful system for managing vital parts because it controls inventory and workflow visually. Its inventory control system visually signals through cards when to reorder parts, lessening the risk of critical shortages and helping maximize inventory cost efficiency [14].

Recent research indicates that Kanban greatly improves SMEs' operational efficiency. Firms that practice this method experience better maintenance planning due to faster turnaround time for spare parts [15]. This method also improves intraorganizational collaboration regarding requisition-based demand forecasting by improving the communication and accuracy of the plans.

In the field of transport, Kanban has also enhanced how companies handle unexpected problems. Improved workflow structures enable SMEs to respond faster when equipment malfunctions, thus helping maintain operational uptime [18]. One transport case study that incorporated the Kanban technique was able to reduce downtime by 30% [20].

To summarize, abundant literature suggests freight SMEs can depend on Kanban for effective streamlined resource responsiveness. In controlled environments, routine maintenance resource allocation is adjusted dynamically, thus expediting response times [18].

D) Autonomous Maintenance and TPM in SMEs

Autonomous Maintenance is one of the elements of the Total Productive Maintenance (TPM) system, and so far, it has worked reasonably well in transport SMEs. This method trains staff to perform preventative maintenance tasks, improving equipment uptime [15]. Studies also show that this type of worker empowerment promotes a collective sense of responsibility, strengthening the relationship between the workers and their machines [20].

Autonomous Maintenance adopters in SMEs report improved operational efficiency as a result of lesser expenditure on corrective maintenance. This is especially beneficial in transport, where mandatory uptime of vehicles and tools is necessary [18]. Machine stoppages diminish as more businesses, especially in manufacturing, use the TPM philosophy and its practices like Autonomous Maintenance [14].

This maintenance technique can eliminate unnecessary service interruptions due to equipment failures, helping a firm improve its managed service quality [15]. Research suggests that ensuring SMEs implement TPM properly increases the Overall Equipment Effectiveness (OEE)—a critical KPI in the competitive transport industry—by nearly 30% [18].

Autonomous Maintenance aids within TPM represent a self-sustained method for SMEs that want to simplify their processes with deeper employee engagement in equipment activation or mobilization.

E) Preventive Maintenance and TPM in Transport SMEs

As with most SMEs involved in cargo shipment, Preventive Maintenance is relatively more pronounced within the framework of TPM. It emphasizes the scheduling of routine maintenance and other servicing activities for known issues as well as potential ones, thereby leading to business processes that are smooth and predictable [21]. In addition, it results in better overall equipment condition, thus improving its useful life and ultimately reducing costs [18].

It has been established that implementing preventive maintenance processes within SMEs helps reduce repair costs and idle time [14]. This is especially important in transport, where downtime can seriously hurt revenue [22]. Companies can use predictive analytics to uncover problem areas before they escalate, thus saving significant time and resources [15].

This approach to maintenance helps firms with compliance, as transport is an industry heavily regulated for safety and dependability [17]. Evidence suggests that SMEs adopting a preventive maintenance strategy attain high performance and enhance their perception as reliable and safety-focused [20].

The overarching goal of Preventive Maintenance within the context of TPM is to help SMEs enhance their operational reliability, reduce costs, and improve their service delivery to customers [18].

III. CONTRIBUTION

A) Proposed Model

In tracking the operational availability challenges of a mid-sized freight and cargo transport company, **figure 1** illustrates a management model designed specifically for the firm. This model integrates Lean Manufacturing concepts with Total Productive Maintenance (TPM) tools in order to create a maintenance system founded on continuous improvement. The model develops in three interrelated phases that are applied in increments. The first step begins with implementing the 5S methodology to establish baseline conditions of order, cleanliness, and standardization in the fleet's workspace. Then, it moves to the advanced stage of training employees and incorporating visual management through Kanban for spare parts and designated tasks. This stage also implements the autonomous maintenance policy, where operators are empowered to participate in routine inspections of the trucks from the driving side. Lastly, the final stage concentrates on a structured visual maintenance scheduling framework to achieve activity tracking and monitoring. The unifying model is aimed at unplanned breakdown reduction while improving vehicle fleet availability and reliability.

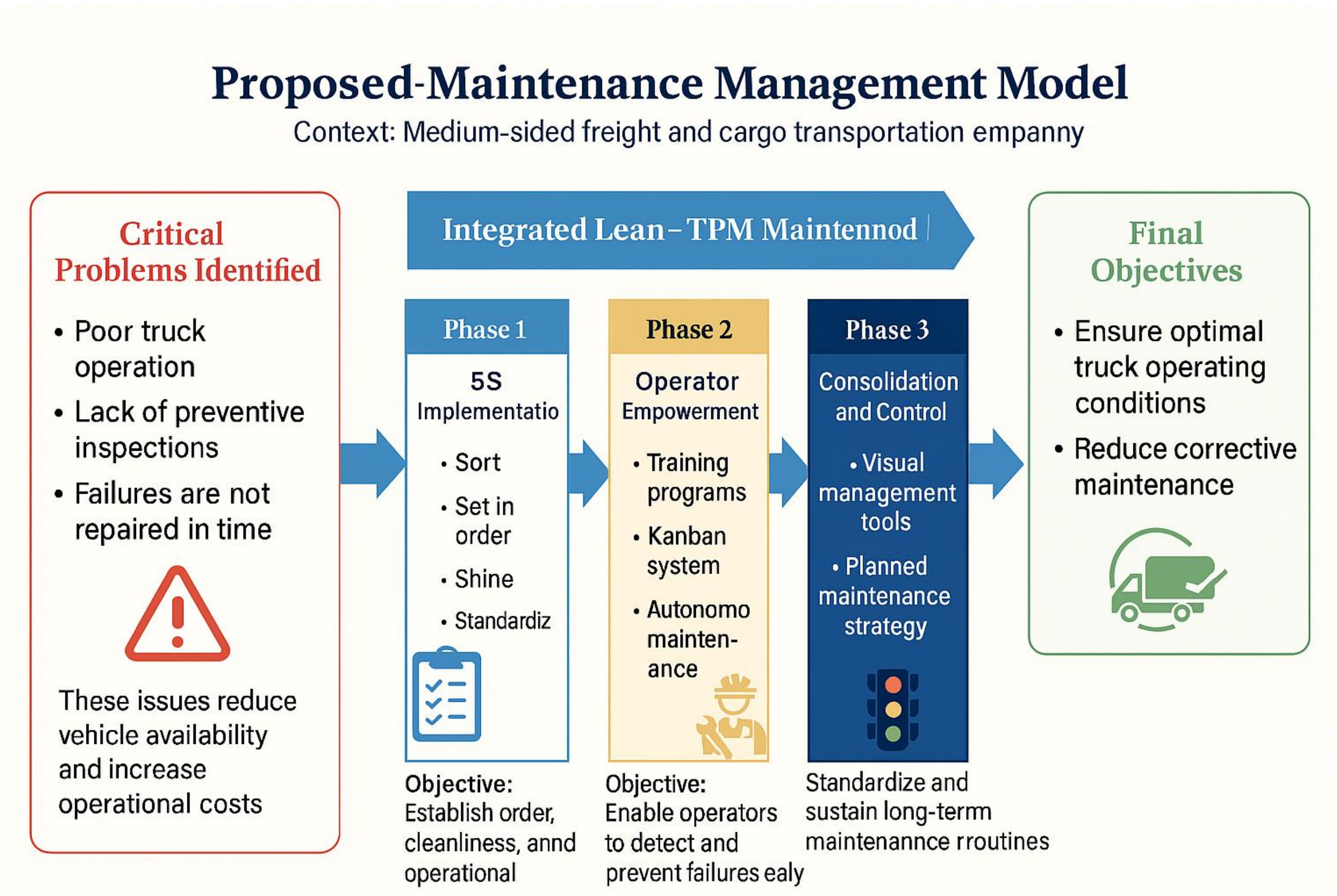


Fig. 1 Proposed Model

B) Model Components

Also, transportation maintenance management is a problem for every organization that wishes to keep the reliability and availability of operational critical assets. Operational and capital constraints faced by medium-sized freight and cargo transport companies often result in an unsophisticated management system. In this context, the management model in Figure 1 is designed as a structured proposal based on Lean Manufacturing and Total Productive Maintenance (TPM) principles. It seeks to add proven industrial tools to logistics operations. The model's focus is not on the mere reduction of corrective failures but rather on introducing prevention through a more systematic, holistic, and inclusive approach that engages operational and maintenance staff. It contributes to the literature as an adaptable and transformable alternative in organizational settings yet still functions as a powerful strategic tool for enhancing accessibility and extending the service life of transport vehicles.

Phase 1: Creating Order and Cleanliness for Sustainable Practices

The first phase of the model builds a strong base with the 5S framework, which catalyzes cultural change for the better in maintenance activities. During this phase, five practices, sort, set in order, shine, standardize, and sustain, are implemented to improve the functionality and safety of working environments within the truck operational areas. The sorting stage involves identifying and removing clutter, such as unnecessary items in the vehicle compartments or maintenance zones. Tools and other essential items, such as components, are organized logically to minimize motion and time lost. Cleaning is more than basic hygiene; it involves promoting ongoing inspections that detect rudimentary signs of deterioration in a mechanical system's components or a malfunction. In maintenance tasks, standardization ensures that all vehicles are routinely maintained on the same consistent baseline, thus defining clear processes and steps that all operators can easily follow. Ultimately, encouraging these practices leads to long-term engagement, disciplined routines active participation from team members. This phase aims to foster and maintain a clean and orderly workplace while building a culture of responsibility and continuous improvement.

Phase 2: Empowering Staff and Fostering Shared Responsibility

Upon establishing the basic structural model, the framework moves to the second stage, which emphasises nurturing competencies and systems that encourage self-governance within the workflows. This phase holistically combines training, the

Kanban system, and autonomous maintenance. All truck drivers and maintenance personnel are instructed on basic vehicle systems and periodic inspections to detect and deal with emerging problems before they cause more serious ones. The training sessions are intended to provide the right Skills and Knowledge and to shift the mindset towards ownership and pride in equipment maintenance. At this stage, Kanban is also introduced to manage the Workflow of materials, spare parts, and jobs at hand as a visual management system. It helps manage delays by improving the visibility of what is needed and what is available. Autonomous maintenance enables drivers to complete basic inspection and preventive maintenance tasks, which relieves specialized technicians and enhances the operator's relationship with their vehicle. Together, these initiatives create a more skilled and committed workforce and a reliable, streamlined system for informed and prompt decision-making.

Phase 3: Building Stability Through Visual Control and Planned Maintenance

The last phase of the model aims for a system's long-term sustainability by aligning visual controls with maintenance planning to stratify controls for maintenance. Here, visual control covers information tools such as signs, indicators, and records highlighting the most important information. These tools enable the operational and maintenance leaders to control all trucks for scheduled tasks and identify deadlines without waiting for reports. In addition to these tools, the fleet operations scenario and the criticality of components determine the preventive maintenance activities for each subsystem and component. This type of planning increases system dependability by anticipating failures and mitigating them beforehand, thus improving the availability of vehicles and decreasing unscheduled downtime. Moreover, the schedule promotes improved personnel allocation, spare parts inventory, and better synchronization of the technical and operational divisions. This way, through a flexible maintenance calendar, this phase caps the model by ensuring that changes made during earlier steps are maintained while evolving the organizational mindset towards integrating maintenance into strategic objectives.

a. Incorporating The Framework of The Organization in the Model

Achieving success with the model hinges on its alignment with the company's organizational processes. This means there is clarity around allocating responsibilities and resources and active engagement in each contributor's respective capacity, from top management to the operators on the shop floor. Integration of the model includes building systems for ongoing evaluation and feedback that support practice improvement as results and conditions change over time. As an example, the model accomplishes, within the organization, the promotion of order, discipline, and effective communication. While the model begins to enhance the availability of trucks, it broadly shifts the perception of maintenance from a reactive obligation to a primary organizational activity essential to operational effectiveness and resilience.

b. Ongoing Monitoring and Performance Evaluation

Following implementation, the organization arms itself with a continuous monitoring system, which is bolstered by key performance indicators to track the success of the new maintenance framework within the organization. The new methods are not only tracked at the technical level, but also with regard to personnel acceptance and response. Periodic internal audits ensure that all three phase practices are followed as designed and intended. Regular Interdepartmental Meetings (IDMs) are also conducted for members to update, report, and discuss any challenges or offer solutions. The organization enhances its focused learning and adaptive learning loops, strengthening its culture of prevention and continual improvement across the company.

c. Lessons Learned and Model Flexibility

When the model undergoes implementation, several practical insights are found. One of the most critical insights is the importance of engaging staff at the front line. Their participation actively strengthens ownership and commitment at work. A different, equally important understanding is that simplicity does not mean something is ineffective. In practice, the tools are low to mid-fidelity and simplistic to the point of being easier to use in the most operationally challenging environments. The model remains replicable with a modicum of tailoring done for each new setting. This rapidly becomes one of the model's foremost strengths, in this case, its ability to transcend disparate sectors facing similar problems associated with maintenance and asset availability.

d. Future Outlook and System Sustainability

Driven by the goals and desire to expand the model to other functional areas and fleet units, the organization actively pursues new opportunities. Also being planned are incorporating digital tools like Computerized Maintenance Management Systems (CMMS) and monitoring in real-time. Other enhancements would help in tracking automation, creating predictive alerts, and overall improving decision processes. Simultaneously, the firm continues cultivating a preventive culture and mindset by investing in employee training. The model's success sustains over time not just on tools and systems, but on unyielding commitment from the entire workforce to the underlying principles. This is why practical steps are taken to integrate the maintenance model into the company's strategic planning to sustain its relevance over time.

The proposed maintenance model is responsive to medium-sized freight transport companies' needs, presenting a well-organised problem-solving approach. Its integration with Lean and TPM enhances vehicle and operational uptime. It is also noted that while effectively implemented, the model reframes maintenance from a routine, responsive undertaking into an anticipatory, strategically planned activity. From a broader perspective, the experience demonstrates how a disciplined approach and adherence to structured frameworks can lead to remarkable results even when resources are constrained. The primary contribution of the model, however, is that it profoundly transforms maintenance management towards more innovative directions. It may also be useful in other sectors where performance-driven asset management is essential.

C) Model Indicators

In order to see how the maintenance management model functioned with regard to practice, the team implemented some measures of performance aligned with the operational reality of a medium-sized freight transport business. These measures were concentrated on evaluating whether the availability of the trucks was improving and whether the maintenance process was improving over time. This systematized assessment helped form some understanding regarding the system's functioning, guiding decisions and facilitating adjustments in the effort toward maintenance when required. This integrated framework improved fleet maintenance in relation to the operational objectives, resulting in enhanced fleet reliability.

a. Total Corrective Maintenance Hours

This indicator tracks the number of hours spent on unplanned maintenance activities. A lower value suggests improved planning and system reliability.

$$\text{Corrective Maintenance Hours} = \sum_{i=1}^{n} \text{Hours}_{\text{corrective},i} \tag{1}$$

b. Availability Rate of Truck Fleet

It reflects how often the truck fleet is operational and ready to be used. Higher availability means less downtime and better performance.

$$\text{Availability (\%)} = \left(\frac{\text{Operating Time}}{\text{Operating Time}+\text{Downtime}}\right) \times 100 \tag{2}$$

c. Economic Opportunity Cost

This represents the financial impact of unavailability. Reducing this cost implies the fleet is idle less often, allowing more deliveries and revenue.

$$\text{Opportunity Cost} = \text{Idle Hours} \times \text{Hourly Revenue} \tag{3}$$

d. Failure Probability During Trips

It measures the likelihood of a truck experiencing a failure during transit. Lower values point to better reliability and maintenance planning.

$$\text{Failure Probability (\%)} = \left(\frac{\text{Trips with Failures}}{\text{Total Trips}}\right) \times 100 \tag{4}$$

e. Preventive Inspection Hours per Unit

This shows the average time invested in preventive inspections for each truck. Increased values usually mean more proactive maintenance and fewer breakdowns.

$$\text{Inspection Hours per Unit} = \frac{\text{Total Preventive Inspection Hours}}{\text{Number of Trucks}} \tag{5}$$

IV. VALIDATION

A) Validation Scenario

The validation scenario was conducted in a case study involving a small-sized transportation company based in Lima, with interprovincial operations in the northern region of Peru. This organization was dedicated to the daily movement of freight and goods using a fleet of trucks. Over the past year, the company faced significant limitations in its operational capacity due to recurring challenges in vehicle maintenance management. Frequent mechanical issues forced a large portion of the fleet into repeated workshop visits, directly affecting productive time and causing delivery delays. This situation disrupted logistical efficiency and impacted customer perception of service quality. Considering this context, the research focused on understanding the root causes of the problem and analyzing its operational impact through a continuous improvement perspective.

B) Initial Diagnosis

The analysis carried out in the case study showed that one of the main challenges was the limited availability of the truck fleet, which stood at 85.81% in the last year—falling short of the 95% benchmark typically referenced in global standards. This shortfall brought about an estimated financial loss of 740,624 PEN, accounting for 19% of the company's yearly income. Four systems were found to be the most frequent sources of downtime: the structure (32%), transmission (29%), electrical (27%), and engine (12%). Structural issues were often caused by bent fenders (18%), broken side mirrors (15%), and worn bumpers (13%). Transmission-related problems came from faults in the electronic module (29%), worn servo clutches (20%), and clutch assemblies (13%). Electrical failures were mostly related to lighting (75%), as well as malfunctions in the fuse box (18%) and battery issues (6%). As for the engine, problems were mainly tied to oil replenishment (22%), turbo components (21%), and electronic fault codes (20%).

C) Validation Design

The maintenance model, which combines Lean and TPM strategies, was implemented through a pilot test at a medium-sized freight transport company. Over four months, the focus was on making the fleet more available and reliable. The team used 5S methods in vehicle maintenance zones as part of the plan, set clear inspection standards, and promoted autonomous maintenance among operators. This pilot relied on real data to understand how the system worked and whether applying it in day-to-day operations made sense. The experience showed the model helped reduce reactive repairs and improved the fleet's overall performance.

a. Implementation of the Proposed Model in the Case Study

Combat persistent inefficiencies associated with unanticipated vehicle downtimes and chaotic maintenance schedules, a maintenance model was developed in a Lima, Peru-based medium-sized freight transport company. The model was based on Lean Manufacturing and TPM approaches, emphasising prevention, more active employee participation, and organized planning. The model was aligned with the firm's operational realities and technical limitations. Its goals were to enhance truck availability, reduce the need for ad-hoc repairs, and facilitate continual improvement. Every strategic component was crafted to tackle diagnosed problem areas pertaining to critical systems within the organization. The process included setting measurable goals, encouraging team participation, and creating feedback mechanisms to support long-term success. What follows is a breakdown of how the model was built and implemented.

b. Initial Planning and Operational Diagnosis

The team thoroughly reviewed 12 months of operational data, including maintenance logs and financial reports. This analysis revealed that truck availability stood at 86.16%, well below the ideal target of 95% typically expected in the logistics sector. About 14,220 hours were lost to corrective maintenance, roughly 19% of the company's yearly revenue. These findings showed a clear need for action. Four systems were mainly responsible for most of the breakdowns: the structural (32%), transmission (29%), electrical (27%), and engine (12%). With this insight, efforts were directed at those high-impact areas, laying the groundwork for a targeted improvement plan.

c. Implementation of 5S for Workplace Organization

One of the first actions was to organize and clean all maintenance spaces using the 5S method. Before the change, nearly half of the tools were either missing, mislabeled, or difficult to find, slowing down work and raising safety concerns. The team reorganized workstations, labeled equipment, and removed unnecessary items from the area. Maintenance staff and supervisors were trained to apply 5S daily. After full implementation, time spent looking for tools dropped by 28%, and small incidents linked to clutter were reduced by 34%. Staff also reported feeling more comfortable and confident in their work environment. The visual order and cleaner spaces laid a solid base for standard procedures and smoother routines.

Figure 2 shows a simple visual guide that helps drivers apply the 5S method in their daily routines. It walks through five clear steps: choosing what's needed, keeping things in place, cleaning regularly, agreeing on how to do tasks, and building long-term habits. The panel encourages organization and care.

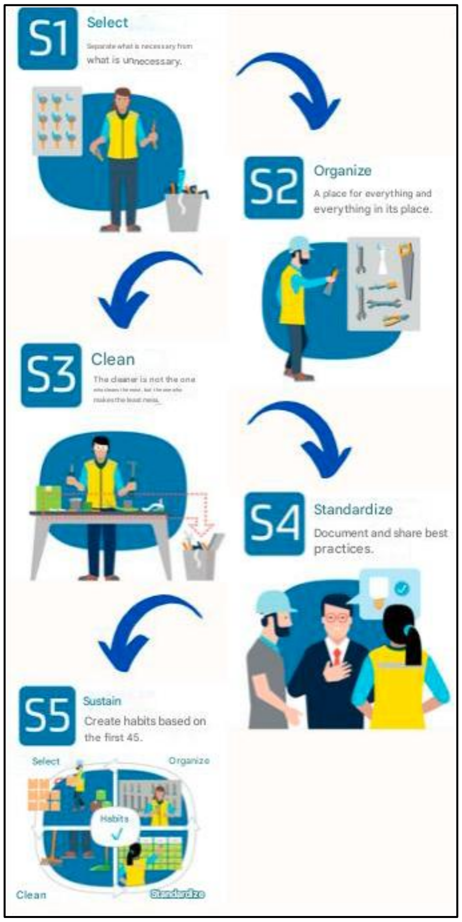


Fig. 2. 5S visual panel for drivers

Figure 3 displays a visual order panel designed for drivers, highlighting the importance of organising the truck cab. It contrasts an untidy cab filled with items with a clean, clutter-free space. The panel encourages good housekeeping habits by showing clear examples of what to avoid and what to follow.

Fig. 3. Visual order panel for drivers

Figure 4 presents a visual cleaning panel that outlines six easy steps for drivers to maintain a clean truck cab. It includes removing trash, sweeping floors, cleaning the dashboard and windows, and eliminating stains. The panel uses clear icons and colors to promote cleanliness and routine maintenance inside the vehicle.

Fig, 4. Visual cleaning panel for drivers

d. Standardization of Maintenance Routines

With the workspace in order, the team tackled the inconsistency in vehicle inspections. These checks lacked formal structure in the past, relying on informal routines that missed early signs of trouble. A new checklist system was introduced for inspections at different time intervals. These were adapted to each vehicle’s needs based on usage and manufacturer guidelines. Mechanics were trained to use the checklists consistently, and supervisors monitored their application. Within a month, adherence to inspection routines rose by 62%, and unplanned service interruptions dropped by 21%. The standard process made documenting issues and identifying patterns easier, helping plan future interventions more effectively.

Table 1 outlines the team designated for TPM implementation. It includes four key roles: a maintenance supervisor, a coordinator, and two lead drivers. Each member was responsible for supporting the structured rollout of TPM practices, ensuring coordination between technical staff and operators throughout the maintenance improvement process.

Table 1. Team for TPM implementation

No	Position	Responsible Person
1	Team Leader	Maintenance Supervisor
2	Team Coordinator	Maintenance Coordinator
3	Team Leader 1	Lead Driver 1
4	Team Leader 2	Lead Driver 2

Figure 5 shows a tyre inspection by a trained technician as part of the preventive maintenance routine. The worker uses proper safety equipment and follows standardized procedures to check the condition of the tires, helping ensure road safety, reduce unexpected failures, and extend the vehicle’s operational life.

Fig. 5. Tire inspection

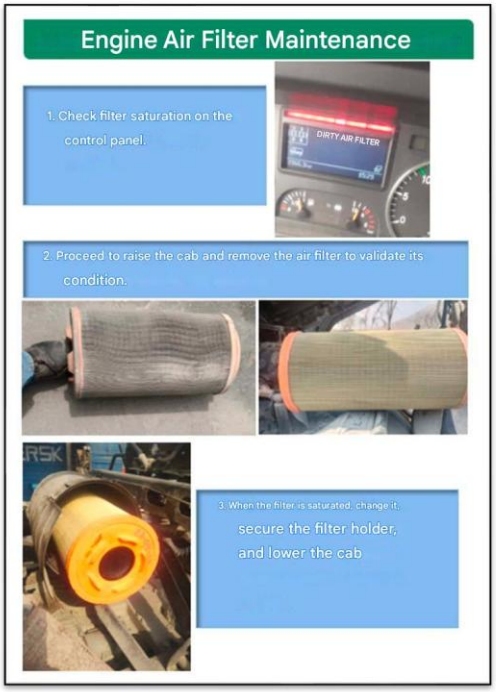
e. Integration of Autonomous Maintenance Practices

In order to share responsibility and increase awareness, drivers were trained to carry out simple vehicle checks themselves. Previously, drivers had little involvement in monitoring the condition of their trucks. The new training taught them to check essential items such as oil, tires, lights, and brake fluids. A Kanban board in the maintenance area helped track who completed inspections and what issues were noted. Two months into the change, 75% of drivers regularly completed checks, and early fault detection improved by 48%. This change not only saved time during formal maintenance sessions but also built a stronger connection between drivers and the condition of their trucks, improving safety and ownership.

Figure 6 presents a step-by-step visual guide for replacing spotlights in trucks. The process begins with identifying the faulty light, blocking the unit, and using a Phillips screwdriver to remove the lens. The bulb is replaced, the cover is reattached, and the system is tested. Finally, the maintenance report is submitted, and the vehicle resumes service. This visual panel promotes safe and orderly maintenance by simplifying each step and ensuring drivers and technicians follow a standard procedure.

Fig. 6. Instruction for changing spotlights in trucks

Figure 7 provides visual instructions for replacing a truck's engine air filter. It starts by checking the alert on the control panel and then inspecting and removing the dirty filter. Finally, a clean filter is installed. This guide helps ensure proper engine performance and supports preventive maintenance through clear, easy-to-follow steps.



Fig, 7. Instructions for changing the engine filter

f. Preventive Maintenance Scheduling and Planning

The next phase involved setting up a preventive maintenance calendar. Using service records and manufacturer recommendations, the team mapped out regular maintenance intervals based on mileage and hours of use. Before this, most maintenance was reactive, often done in response to failures. With the new system, 68% of interventions were preventive. The average time between failures grew from 85 to 117 hours, reflecting better reliability. Spare parts were also ordered in advance, avoiding last-minute requests and delays. Assigning clear responsibilities and syncing the schedule with operations reduced service bottlenecks and helped ensure trucks were available when needed most.

Table 2 shows the monthly schedule of truck inspections distributed across four weeks. Each vehicle is assigned a specific week for its preventive check, ensuring maintenance is spread evenly throughout the month. This planning approach helps organize workshop capacity, avoid overlaps, and maintain consistent fleet availability without disrupting operations.

Table 2. Scheduled Inspections – Monthly

No	Plate Number	Week 01	Week 02	Week 03	Week 04
1	ACI-819	X			
2	ACI-893	X			
3	ATR-805	X			
4	ATT-711	X			
5	AWS-858	X			
6					
7					
8	AZR-931		X		
9	AZS-724		X		
10	AZS-809		X		
11	AZS-899		X		
12	AZT-866		X		
13					
14					
15	BEC-721			X	
16	C2J-827			X	
17	C9A-868			X	

18	C9S-760			X	
19	C9V-701			X	
20					
21					
22	D8T-791				X
23	D8T-849				X
24	F6F-868				X

g. Visual Management and Performance Tracking

With the performance, dashboards were placed in shared work areas to keep things transparent and easy to follow. These showed key metrics like availability rates, maintenance hours, and task completion. The charts were updated every week and used in team meetings to review progress and decide on adjustments. Switching to digital reports made accessing information easier and improved team communication. Response times to maintenance needs dropped by 43%. Managers could also see how each team member contributed, which helped encourage accountability and recognize good performance. Visual tools played a big part in keeping goals visible and actions aligned with actual needs.

h. Staff Training and Cultural Change

Improving the process required more than new tools—it needed people to think differently. A series of workshops was organized to teach mechanics, drivers, and supervisors about lean thinking, TPM principles, and how to use the new systems. Over three months, most employees completed at least two sessions, totaling around 12 hours of training each. Survey results showed a 72% increase in confidence and a 57% rise in suggestions for improvement. Feedback boxes and open discussion spaces were added, encouraging collaboration and new ideas. Over time, maintenance was no longer viewed as just fixing things when they broke but as a shared responsibility across the team.

i. Results of the Pilot and Continuous Improvement Outlook

By the end of the pilot, the model had led to noticeable gains. Availability went from 86.16% to 92.24%, and corrective maintenance time was cut by over half. Financial losses from downtime dropped from S/. 740,624 to S/. 304,478. These numbers reflected more efficient use of time and better planning. The company set up a team to monitor ongoing progress and evaluate monthly results. Encouraged by the outcomes, they began preparing to roll out the model in other areas and considered adding more digital tools to keep improving. The pilot showed that meaningful improvements were possible with the right tools and a clear structure.

D) Results

Table 3 shows the main outcomes of the pilot validation, reflecting the impact of implementing a maintenance management model based on Lean Manufacturing and TPM tools. One of the most notable results was the drop in corrective maintenance hours, which went from 14,220 to 5,846—an improvement of nearly 59%. The fleet's availability also improved, reaching 92.24% and reaching the global reference target of 95%. The cost associated with downtime was significantly reduced, as was the failure probability during trips, which fell from 16.00% to 6.80%. Additionally, drivers' time on preventive inspections increased from 1.5 to 3.5 hours per unit, highlighting a stronger shift toward preventive practices. Together, these results confirmed that the applied model addressed the core problem and brought clear operational improvements for the company's day-to-day transport activities.

Table 3. Results of the pilot

Indicator	Unit	As-Is	To-Be	Results	Variation
Total corrective maintenance hours	Hours	14,220	8,000	5,846	-58.89%
Availability rate of truck fleet	%	85.81%	95.00%	92.24%	7.49%
Economic opportunity cost	PEN	740,624	450,000	304,478	-58.89%
Failure probability during trips	%	16.00%	10.00%	6.80%	-57.50%
Preventive inspection hours per unit	Hours	1.5	3	3.5	133.33%

V. DISCUSSION

The results of this study are consistent with previous research on the application of Lean and TPM in SMEs. The increase in fleet availability and the reduction in corrective maintenance hours mirror the improvements reported by Sharma and Sharma, who demonstrate the benefits of integrating TPM into SME operations [1]. Similar outcomes were observed by Sahoo, where TPM adoption led to higher availability levels in manufacturing settings [8]. Additionally, using Lean tools such as 5S and Kanban aligns with the contributions of Qureshi et al., who emphasize their impact on operational efficiency and sustainability [3]. These parallels reinforce the value of combining both approaches to enhance maintenance performance and foster continuous improvement.

This study, however, is subject to certain limitations. Its findings are based on a single case study within a specific operational and geographic context, which may limit broader applicability. The four month duration of this implementation period constrains the evaluation relating to assessing long-term impacts. Moreover, the relative economic factors, financial dimensions, and culture were not investigated in depth, which creates gaps that could affect the model's prospective success and sustainability.

The empirical evidence from our study indicates that there is indeed some level of weak integration with Lean and TPM practices, suggesting that SMEs could take advantage of a gradual and well-organized implementation of these systems. This theory allows for enhanced control, incentivizes workers through decreased idle time, and empowers service staff to operate more autonomously through remote monitoring systems. These systems bolster order and service reliability, which is important in transportation and logistics.

Future studies could expand the application of this model to other regions or industries to validate its adaptability. Longitudinal research may reveal the sustained impact of these practices over time. Exploring digital tools such as CMMS and IoT, analyzing return on investment, and investigating cultural and leadership factors may also strengthen the understanding and scalability of Lean-TPM strategies.

IV. CONCLUSION

The research shows how merging Lean Manufacturing principles alongside Total Productive Maintenance (TPM) within an organized management framework substantially enhances the operational efficiency of a medium-sized freight transport company. Implementing a phased strategy begins with the organization of the workplace, followed by training and autonomous maintenance. Then it ends with scheduling preventive maintenance, resulting in improved fleet availability, reduced corrective maintenance hours, and decreased costs related to these maintenance activities. Also, delegation of routine inspection tasks to drivers enhances ownership of responsibilities and cultivates a positive attitude towards maintenance.

This research is important in regard to SMEs since they tend to operate under resource constraints, yet they have to meet high demands in service dependability. Focusing on practical auxiliary tools and visual systems provides simpler solutions to operative problems instead of elaborate models lacking feasibility for smaller entities. The model fills an important operational void and illustrates the possibility of achieving significant outcomes through small steps and collective effort.

Perhaps one of the most important findings of this research is the empirical framework of an adjustable and expandable model, which is its principal characteristic. This research deviates from focusing on Lean or TPM approaches in singularity and offers a unifying narrative: integrating routine maintenance activities with strategic planning.

The case study reveals that even the most basic practices can shift maintenance from reactive to proactive when applied consistently.

Other regions and sectors may be studied to assess the applicability of this model in different contexts. The model may be refined further by integrating the analysis of digital maintenance systems with long-term cost-effectiveness. Organizational behavior, the impact of leadership, and culture may help explain the sustaining of those improvements. These are some avenues that can further explore these findings to foster adoption and advance the evolution of maintenance practices in SMEs within the logistics industry.

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