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LEAN SERVICE MODEL WITH SIMULATION IN ARENA TO IMPROVE RESPONSE TIME OF THE TECHNICAL SERVICE IN A PERUVIAN SME

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***Abstract*— The services sector has maintained sustained growth in recent decades, becoming one of the sectors contributing most to the global economy. However, the characteristics of these activities represent a challenge to companies in the sector, which seek to be more competitive in the presence of new technologies and a globalized world. In this context, the companies that offer field service for the maintenance of machinery and equipment present problems in planning their activities due to the uncertainty in demand, the distances to be covered, and to comply with the expected response time of the client. Therefore, to solve these problems, this article proposes applying manpower planning strategies and lean tools to reduce the response time in field service. The simulation models are based on these strategies and were structured and validated using Arena simulator. A 7% improvement in service level was obtained, considering the contractual response time offered to customers. The proposal will provide alternatives for field service planning and provide companies with tools to increase their competitiveness.**

***Keywords—lean service, field service, simulation, standardization, VSM** (keywords)*

I. INTRODUCCIÓN

Currently, the service sector contributes more than two-thirds of the world's GDP and employs almost half of the economically active population worldwide [1]. As for the companies in the sector, they have not responded in the same way to the effect of globalization and competition [2]. This is due to the unique characteristics of services, such as the heterogeneity of demand, intangibility, and the client's presence, which has delayed the spread of Lean practices and the application of technologies [3]. In this article, we focus on business-to-business or B2B field service related to the maintenance of equipment and the supply of spare parts and consumables. A company that provides this type of service is in charge of sending technicians to carry out maintenance work on geographically dispersed machines [4]. Maintenance tasks can be preventive, scheduled in advance, and corrective, which occur in the event of an unforeseen failure or defect of the equipment. The latter presented as stochastic events, which means a challenge in planning field services by complying with the response time promised to the client and attending to pending preventives. In the same way, another series of challenges are presented, such as the management of spare parts, the variation of the service time, and the customers' geographical distribution.

Various authors have studied the problems presented in the field service. One of the first identified problems was the "vehicle routing problem" which focused on reducing clients' transportation time. The design of algorithms to optimize the routes and the distribution of technicians was proposed for this problem. Because of the complexity, it was sought to decompose it to find alternative solutions [5]. The VRP is considered the base problem in the field service. Numerous exact and approximate solution methods have been developed for different variants of the routing problem [6]. In recent decades, software development for route optimization or geolocation-based systems has presented new solution alternatives, one of these being the simulation of discrete events using specialized software that increasingly supports more complex models that can be adapted to represent the operations of a company. These simulation models can evaluate different planning strategies and evaluate system changes in a “safe” environment. [7].

The strategies that will be addressed in this article are related to the planning of the workforce or work personnel. In the companies that offer field services, the technicians are mobilized to carry out maintenance tasks. Some of the most used strategies for personnel planning are the policies for the dispatch of technicians [8], the grouping or geographical distribution of clients [9], and the qualification of technicians according to their experience or ability [10]. It should be noted that these strategies are focused on planning at the tactical and strategic level in a company since other strategies focused on decisions at the operational level use Decision Support Systems (DSS) to verify the status of the equipment (Condition Based Maintenance) or picking routes in real-time.

Many research claims that applying manpower planning strategies can reduce field service response time by efficiently utilizing and mobilizing human resources, which directly improves the service level offered by the company. Likewise, Lean tools such as the VSM as a diagnosis tool graphically represent the workflow subjected to analysis. Subsequently, the standardized work allows monitoring the processes involved and allocating them to continuous improvement.

Given the precedents of the studies on field service industry, the tools and strategies detailed in this article have been scarcely studied. However, the existing evidence on its use in other business areas within service companies supports its effectiveness, improving the company's profitability, beneficial changes in processes, and the development of continuous improvement skills [11] [12]. The following research work has been divided into 4 sections: state of the art, contribution, validation of the model, and conclusions.

II. STATE OF THE ART

A. *Lean Field Service*

The Lean Service approach applied to field companies denotes a framework of tools previously used in manufacturing companies. According to [13], this modality of implementation in goods manufacturing companies represents, for the most part, a reference for recent advances in service companies, which they called "Lean Service". Among the main tools used in the Lean field is VSM, such as the diagramming of activities, highlighting those that provide added value to the process, reducing production times, and proposing improvements for those that do not add value to the information flow [14].

B. *Manpower Planning*

For an efficient deployment of the field service, it is necessary to plan both at the level of the processes to be followed to meet the requirements of the clients, preparing the inventory of spare parts and consumables used with the technicians, and the planning of the labor required for meeting the demand for maintenance requests. The latter's focus is reducing transport time and the low availability of technicians. An improvement in these implies a reduction in response time, which will allow maintaining a level of service corresponding to what the customer expects. Some of the strategies proposed by different authors involve the technician's skills, the areas where the clients are located, and the dispatching policies. Subsequently, these improves are evaluated through an event simulation software carrying out a comparison of the outputs with the actual model.

C. *Standardized Work*

The process standardization is based on establishing and registering a set of solutions with the expectation that these are continuously recorded during a specific period with a user-friendly format, the definition of KPIs for the model to control them and analyze them in the future [15]. This model lays its foundations on the success of the standard in the company portraying improvements of 15% in operating times 18% in reduction of defects, given that the successful performance of each of the previously detailed processes is interpreted with the correct distinction in each of them developing indicators of good practices and guaranteeing continuous improvement.

III. CONTRIBUTION

A. *Model Basis*

The lean methodology applied in service companies offers a range of tools for diagnosing the company's current situation and identifying the change that will be eliminated later through applying a tool as a compliment [16]. If we combine any of these with the strategies for the planning of field services, many of the problems presented can be solved, and the use of Lean tools in the services sector will be promoted [17]. To improve response time indicator and after an exhaustive review of the literature, it was concluded that using a set of lean tools and strategies for workforce planning makes it possible to achieve the proposed objective.

TABLE I COMPARATIVE MATRIX OF THE PROPOSAL COMPONENTS VS STATE OF THE ART

Components	**Component 1: Lean Field Service**	**Component 2: Manpower Planning**	**Component 3: Standardized Work**
Cavdur, F., Yagmahan, B., Oguzcan, E., Arslan, N., & Sahan, N. (2019)	VSM	Dispatching Policies	-
Murugesan, V., Jauhar, S, & Sequeira, A. (2021)	VSM	-	Standardized work
Chan, Chi On Tay, Huay Ling. (2018)	-	-	Standardized work
Hertz, P., Cavalieri, S., Finke, G. R., Duchi, A., & Schönsleben, P. (2014)	-	Dispatching Policies, Districting, Technician Qualification	-
Proposal	VSM	Dispatching Policies, Districting, Technician Qualification	Standardized work

B. *Proposed Model*

The model proposed in this research article has as its primary motive the fusion of the Lean tools and Manpower Planning Strategies, previously detailed in state of the art, to increase service level in field service maintenance activities. Lean methodology is used in many service companies for improving processes. In this case, VSM will be applied to understand the current situation. Also, the standardization of processes lays the basis so that the improvements proposed in the model remain part of the culture and philosophy of the company, being adjustable at different levels of the organization and encouraging their subsequent supervision and control of their continuous improvement. The set of strategies allows improving the company's current situation by using work personnel efficiently, considering their skills, transporting less distance between clients, and setting policies that will allow technicians to accomplish client's requests in time.

Districting: For this strategy, customers who are geographically distributed in cities or regions will be clustered. The idea is to group customers so that a specific group of technicians oversees a specific area to avoid long journeys. This strategy is focused on reducing transportation time. The city is "divided" in two zones, north and south, where a group of technicians will only attend north, and the rest will attend south. Finally, a simulation model will represent both current situation and the proposed strategy and the outputs will confirm if there's and improvement in the proposed strategy.

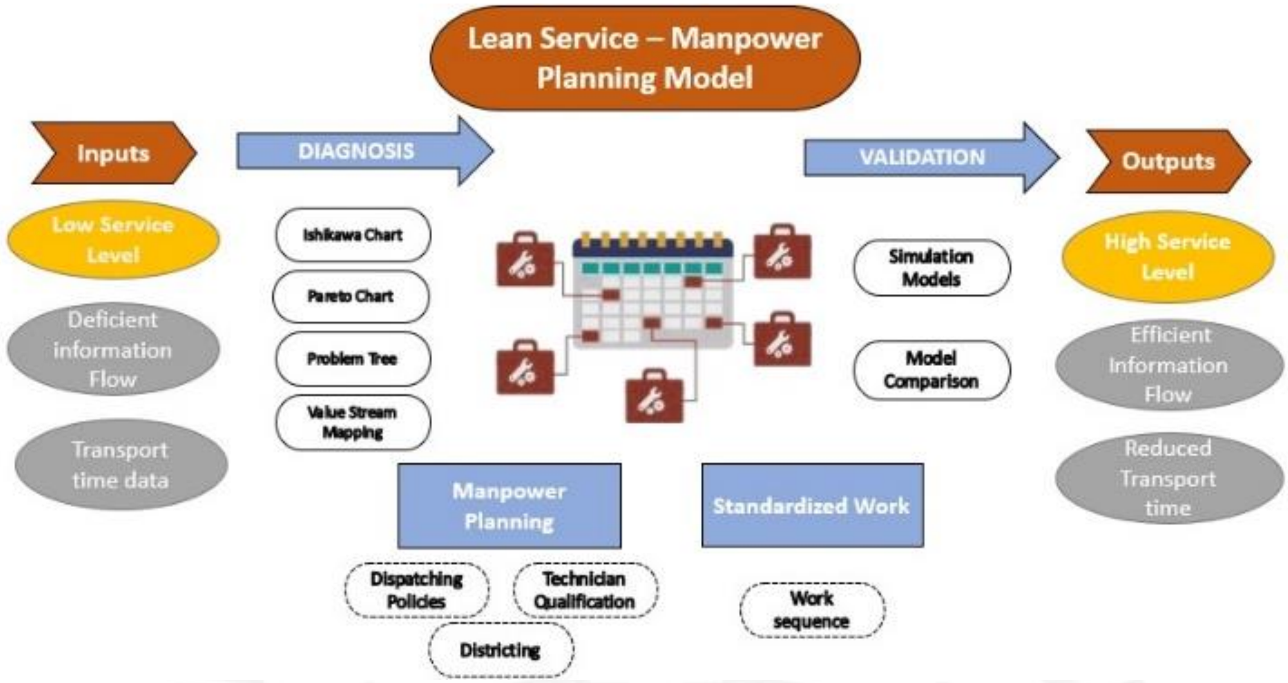

Fig. 1. Proposal Model

The presented model is focused on reducing response time in maintenance service on field services in technical service department in a Peruvian SME, whose actual situation delivers non-compliance of this indicator, causing client's dissatisfaction, economical penalties and losing potential new contracts.

C. *Model Components*

Manpower Planning: From the diagnosis made to the company, strategies are proposed to improve the system's inputs, three strategies will be proposed, and each one will have a different approach.

Dispatching Policies: This strategy focuses on meeting the client as soon as a call arrives. For this, deployed technicians will prioritize failures over preventive requests, meaning that when a customer calls, the first technician to complete any service will answer the customer's call, and pending preventive maintenance will be rescheduled. In the current policies, the closest technician to the customer is selected, and the customer will wait until the technician is free to attend to the request. Finally, a simulation model will represent both policies and the outputs will confirm if there's and improvement in the proposed strategy.

Technician Qualification: In this strategy, technicians are classified according to their ability to operate so that maintenance tasks are assigned according to the expertise of each technician. Each technician may attend a specific type of request, or a group of technicians will be selected to attend a type of request, there is also the possibility that all attend any type of request. This strategy is focused on reducing service time and increasing technician availability. Finally, a simulation model will represent both current situation and the proposed strategy and the outputs will confirm if there's and improvement in the proposed strategy.

Standardized Work: In this stage, the data obtained because of the improvements previously portrayed is collected, in this case, the activities that do not add added value in the information flow are eliminated, which allow the reduction of times in the level of the company and the elaboration of Gantt charts for the implementation of improvements. Finally, operation manuals for the dispatcher will be developed, and a future state VSM will be portrayed by contrasting the previously analyzed information.

D. *Indicators*

The indicators that will be used to evaluate the improvements obtained through the model based on Lean Service and planning strategies will be presented below:

- *Response time*: This indicator measures how long it takes the technician to arrive at the customer's facilities from the moment the request arrived and was assigned to it.

Objective: Reduce the response time to the point that the contractually agreed upon with the client is met.

- *Service level*: Since each client requests a different response time, the clients will be classified according to this time and the service level will be measured.

Objective: Maintain the service level above 90% for all clients. Regardless of the requested response time.

$$Service\ level = Number\ of\ requests\ on\ time\ /\ Total\ of\ requests$$

IV. VALIDATION

To validate the information obtained and the improvements in the proposed model, the Arena simulation software was used to develop simulation models and validate and test using graphical tools, obtaining essential data for the corresponding analysis with the input and output variables and the cycle time of the simulation model.

A. Initial Diagnosis

After collecting data and status of the company at the beginning of the investigation, it was possible to identify the main problem of the company, which is the high response time of the company, which causes loss of customers, the most important is the Core customers of the company being $ 25,000 per year, with the economic impact being 3% of the company's income. It should be noted that the average of the companies in the field in the customer satisfaction survey is 75%, while in the case of analysis, it is 55%. The leading causes of these problems are delays in the flow of information, the limited availability of technicians and a high transport time.

B. Validation Design

The Arena software was used to validate the proposals, simulating the company's operations from Monday to Friday for 52 weeks, so the simulation lasted 260 days. A flow diagram in Fig 2 represents the original model, this has as its central entity the requests for both preventive and corrective measures and the technicians as resources.

The current situation was modeled in Arena with an optimal number of repetitions of the original model was calculated as 188 with an error of 0.5%. The results are detailed in Table III. The outputs were compared with the AS-IS (current situation) shown in table II where it shows that the Original Model represents the enterprise's current situation.

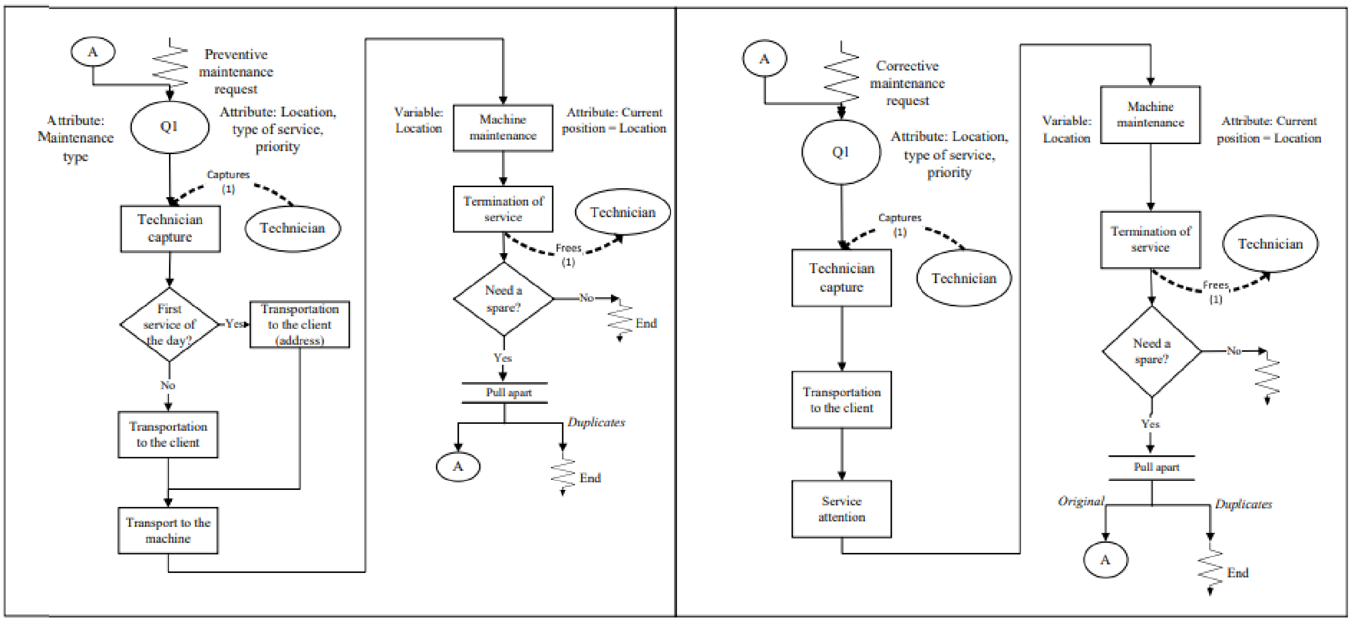

Fig 2. Representation

TABLE II. TABLE OF INDICATORS

Indicator	AS IS	TO BE
Response Time	126.1 minutes	114.5 minutes
Service Level (2 Hrs)	70.1%	90%
Service Level (3 Hrs)	85.6%	90%

C. Improvement – Proposal Simulation

For the improvement proposals, a model was developed for each of these where the main changes concerning the original are the logic of the model, but not in the entities and resources. To analyze the effect of the implementation of these tools, a simulation model was developed in Arena, which showed that the response time was decreased and an increase in the level of service to the most critical customers. The system was represented from the arrival of maintenance requests, the technician's assignment, the technician's transportation, the attention, and closure of the service.

For the proposal simulation, these were elaborated, taking into count the strategies of workforce planning. Three models were developed, each one of them considering a different strategy. To run the models in the Arena simulator, 188 repetitions were used where every model showed different outputs results. These simulation results are compared to the original model in the following table.

TABLE III. ORIGINAL SIMULATION VS PROPOSED MODELS

Indicator	Response Time	Service Level (2 Hrs)	Service Level (3 Hrs)
Original model	128.46 min	72.52%	84.46%
Proposal Model 1 (Dispatching policies)	117.7 min	93.7%	96.7%
Proposal Model 2 (Techinitian Qualification)	124.8 min	72.50%	96.1%
Proposal Model 3 (Districting)	104.7 min	77.55%	88.7%

The results of the simulation presented different improvements in each of the proposals. Response time was decreased in every proposal, but the real impact is presented at the service level as it represents the accomplishment of the contractual response time. The main results are the following:

- Response time was reduced from 126.1 minutes to 104.7 minutes in the third proposal, which makes technicians lose less time in transportation and can complete more requests.
- Service level was increased by 7% and 5% in the first proposal, achieving the main objective of the proposed models.

On the other hand, each proposal on its own presents an improvement to the original model. The idea is to implement these proposals individually or combined depending on the company's needs and resources. The main contribution of the research is to present a set of strategies that will upgrade service value and increase the service level in field service maintenance as many companies still rely on traditional methods for service planning.

V. CONCLUSION

The results demonstrated the possibility of reducing transportation time by up to 18% thanks to the Districting strategies and improving service level indicators of 2 and 3 hours by 7% and 5%, respectively.

Based on the data resulting from the simulation in the Arena simulation software, the importance of the tools previously proposed in the proposed model could be validated and rectified, and their effectiveness demonstrated in a Lean Service environment.

This set of tools met the expected reduction percentage for losses per Core customer in the company. The analysis of the applicability and effectiveness are topics part of the main matrix of the Lean Field Service environment to encourage research to enhance the proposed model.

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