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Research article

Proposal for an integrated SIPOC-VSM model: A case study in an automotive after-sales services workshop☆

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ABSTRACT

Continuous improvement methodologies, particularly Lean and Six Sigma, have been extensively applied in manufacturing; however, their implementation in the service sector presents significant challenges due to the inherent intangibility, personalization, and variability of service processes. Existing literature offers limited guidance on systematically integrating Lean and Six Sigma tools to address these complexities, particularly in industries such as automotive workshops and automotive insurance, where research remains scarce. This study proposes a structured integration of Value Stream Mapping (VSM) from Lean Management with the Suppliers, Inputs, Processes, Outputs, and Customers (SIPOC) framework from Six Sigma, forming a novel model named *Integrated SIPOC-VSM Model* (IMSV). While VSM and SIPOC are occasionally combined in industrial settings, no standardized or systematic methodology exists for their integration. IMSV was developed and adapted to the specific context of a collision repair workshop within a collision-avoidance assistance (CAA) service provider, modifying the SIPOC framework by incorporating an adapted VSM within the Process stage. The primary objective of IMSV is to streamline and reorganise activities within the repair process, enhancing efficiency and fostering continuous improvement. The results demonstrate that IMSV effectively redistributed responsibilities among process stakeholders, reduced activities redundancy, and optimized workflow, leading to a 30% reduction in the total number of process activities identified in the workflow. These findings highlight the potential of IMSV to address the operational inefficiencies prevalent in automotive workshops, filling a critical gap in the literature and providing a replicable model for similar applications in the automotive service, insurance sectors and in the service sector overall.

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1. Introduction

In the current macroeconomic scenario, companies in the automotive industry face evolving challenges due to sectoral changes. A strategic approach is essential to fortify global competitiveness by enhancing products and services [1]. Lean Management is a key strategy aimed to improve overall company performances, specifically focusing on production quality and profitability and reducing wastes. It transforms operational processes, emphasizing a culture of continuous improvement and innovative leadership. Employees are expected to align with the organization's vision, fostering a collaborative atmosphere for meaningful contributions [2]. Lean Management's applicability extends beyond industrial organizations, as highlighted in the majority of the available scientific articles.

Lean Six Sigma is a widely adopted approach that combines Lean and Six Sigma methodologies to enhance business process efficiency and quality [3]. Lean Management targets waste elimination and continuous improvement, while Six Sigma focuses on reducing variation and enhancing process quality. Together, these methodologies provide a framework for ongoing business process improvement, resulting in increased efficiency, reduced defects, and improved customer satisfaction [4].

While initially associated with the secondary sector, Lean Management methodologies are increasingly influential in the tertiary sector. Dependencies between sectors, such as economic reliance, profit margins, growth potential, innovation, long cycle times, and customer interaction, play a crucial role in various industries [5]. The application of these methodologies has the potential to further develop the automotive market.

When an accident occurs, typically involving two or more vehicles, there is a need to involve the vehicle insurers (which may be the same for multiple vehicles). These insurers aim to assess the vehicle damages and fault in the process, which will determine which insurer will invoice for the repair. This assessment process relies on the available and known legal documents, along with subsequent appraisal [6]. The appraisal is conducted to provide an evaluation of a particular accident. It requires the participation of a qualified technician from the insurer's side to ascertain liabilities regarding the incident. Then further steps are taken to provide successfully this service, which often entails unforeseen interruptions and deviations from the standard procedure. This leads to increased variability [7], and therefore, increased costs [8].

With the aim of improving production processes and consequently increasing productivity, Lean tools such as Value Stream Mapping (VSM) are typically employed. This tool can map the entire production process from raw materials to delivery to the end customer, compiling all activities. However, in the case of services, this activity can become significantly more complex due to its variability. When improving procedures in service industries, it is necessary to use a different type of VSM, allowing it to better handle the variability present in the tertiary sector.

For the present research, a detailed study was carried out aimed at integrating a methodology capable of improving the processes of a service company in the automobile industry. It was possible to observe various approaches that introduced tools from the Lean Management and Six Sigma methodologies. However, none of them presented a way of reorganising and improving processes in a simple, innovative way that allowed team building collaboration. The databases of scientific articles were even scarcer in relation to the automotive service industry. As a result, there was a need to develop a model that not only met the requirements of Caetano Auto Alfragide (CAA), the company in which the study was carried out, but also to create a model that could be applied to various industries, particularly in the service sector. Analysing several scientific articles with different approaches, it was possible to define which tools would be most effective for the specific case of CAA and for future approaches in other companies. Thus, a new model is developed to bridge this gap, named Integrated SIPOC-VSM Model (IMSV), that adequately integrates the Lean tool called VSM [9], and the Six Sigma tool named Suppliers, Inputs, Processes, Outputs and Customers (SIPOC) [10]. The development of this tool is based on the available literature but has significant changes due to its application in this case study. This was carried out in a service company in the automotive sector, more precisely in the collision area, whose activity includes repairing body damage to motor vehicles of various brands.

Despite the well-documented effectiveness of Lean and Six Sigma methodologies across multiple sectors [11,12] notable gaps remain in their application to specific operational contexts. First, although the SIPOC framework has been employed in domains such as information technology, manufacturing, supply chains, healthcare, and higher education, its integration with complementary Lean tools has received limited scholarly attention. In particular, empirical studies examining the combined use of SIPOC and VSM are scarce, restricting a more comprehensive understanding of how these approaches may jointly support process analysis and improvement. Second, while Lean and Six Sigma have been widely investigated in manufacturing and general service environments, their application within automotive workshops and the automotive insurance sector remains insufficiently explored. These settings involve distinctive challenges, including high process variability, strong interdependence among stakeholders, and considerable financial exposure to operational inefficiencies. Addressing these gaps calls for further research aimed at developing and evaluating integrated improvement models that combine SIPOC with Lean methodologies in automotive service and insurance contexts.

The deployment of IMSV facilitates a systematic documentation of existing workflows, enabling the identification of inherent inefficiencies and the subsequent derivation of waste-reduction strategies. By codifying these improvements, a future-state procedure is established. Furthermore, peripheral enhancements targeting activities outside the primary process are integrated, culminating in an IMSV framework designed to optimize claims repair operations within the CAA collision department.

This study builds upon the master's dissertation of the first author [13], which provided the initial basis for the development and application of the Integrated SIPOC-VSM Model (IMSV) in the case study presented here. The present manuscript further develops and restructures this previous work for a scientific journal context, with an expanded methodological description and a more systematic analysis and discussion of the results.

The remainder of this paper is structured as follows. Chapter 2 presents the literature review, covering the theoretical foundations of Lean and Six Sigma, the principles of VSM and SIPOC, and existing hybrid frameworks, with particular attention to their application

in service and automotive contexts. Chapter 3 introduces the proposed Integrated SIPOC-VSM Model (IMSV), detailing its conceptual design, methodological rationale, and step-by-step implementation procedure. Chapter 4 describes the case study conducted at CAA, including the organizational context, data collection process, model application, and development of current-state and future-state process maps. Chapter 5 presents and discusses the results of the IMSV implementation, analysing process reductions, workload redistribution, and overall performance implications. Finally, Chapter 6 concludes the paper by summarizing the main contributions, outlining limitations, and proposing directions for future research and broader application of the model.

2. Literature review

VSM is a Lean tool created by Womack and Jones in their 1996 book "Lean Thinking", which stands for Value Stream Mapping. VSM, as the name suggests, is used to map the flow of value in a given production process, reducing or removing the various wastes present within it. This value stream is assessed by looking for added value and its opposite, covering the processes from raw materials to the delivery of products to the customer [14], [15].

However, in Ref. [16], there is a significantly different approach, which is poorly represented in the scientific literature. It has a graphical form similar to *Magikami* [17] and an example can be seen of this type of VSM in the model in Fig. 1. The Japanese approach to visual management in the implementation of TQM and Lean [18] advocates for the use of visual tools, including coloured cards, tags, and signals [19]. In this model, the main difference is the identification of the processes, which in this case is presented in a much more practical way, mainly using post-its. They need to be defined more broadly, as represented in Fig. 1 by orange post-its. They then need to be detailed, as can be seen in Fig. 1 by the green post-its, so that the entire associated process is described. The aim is for the whole team to be able to complete each process with all its activities. This cycle should be repeated until the entire process has been defined. If there is a need to specify WIP or stock between processes, these need to be identified as shown in Fig. 1 by the red rhombus post-its.

In the final phase, a number of KPIs should be represented in relation to each process and consequent activities. This makes it possible to quantifiably evaluate the model and its results. Two of the most important KPIs are the time taken for each process and the waiting time between two processes. With this data it is possible to calculate the total time taken to produce the products or services provided to the customer [9].

2.1. SIPOC tool

The SIPOC model aims to define the scope of the project at an early stage in order to find areas where the process can be improved. This model also serves to define the entire process, transforming inputs into outputs, thus leading SIPOC to be considered a high-level process mapping model [20–22]. It's used to align stakeholders, define project scope, and identify improvement opportunities at a macro level, which are characteristic of high-level process mapping tools. This is done through a graphical representation of the



Fig. 1. – VSM using Post-its.

macro-process, where the suppliers and necessary inputs are specified. Typically, the process is represented using a flowchart, the outputs generated are specified and finally the customers who will obtain the outputs as value are designated. As can be seen in Fig. 2.

2.2. Lean and Six Sigma improvement techniques in automotive workshops

Although Lean and Six Sigma methodologies have been widely studied across manufacturing, healthcare, and service sectors, such as the insurance industry [23–27], their application in automotive repair workshops and automotive insurance operations has received comparatively limited scholarly attention. Existing studies provide useful insights into process improvement in workshop environments; however, systematic investigations tailored to the specific operational context of automotive repair and its interaction with insurance processes remain scarce. This context is characterised by complex interdependencies between repair quality, turnaround time, claims handling, and customer satisfaction, which warrant further focused research.

Several studies illustrate the potential of Lean and Six Sigma tools in workshop settings. In Ref. [28], the authors apply an 8D-based Lean model to improve service processes and Toyota's Fix-It-Right (FIR) rate. The framework addresses key dimensions such as diagnosis, problem analysis, action planning, and evaluation, supported by tools including VSM, process mapping, and SERVQUAL. Following implementation and employee training, the FIR improved by approximately 5% within ten months, alongside gains in productivity and reductions in rework and idle capacity.

Similarly [29], examines waste reduction in seven automotive workshops, focusing on defects, waiting, and inventory. Proposed countermeasures include poka-yoke for error prevention, resource reallocation to reduce waiting, and visual production planning to limit work-in-progress and space constraints. These interventions demonstrate how Lean principles can be adapted to service-oriented workshop environments.

In [30], a Lean Six Sigma (LSS) programme based on the DMAIC cycle is introduced following a Voice of the Customer (VOC) analysis. The study employs tools such as SIPOC, CTQ trees, 6S, Kanban, standardisation, and poka-yoke, supported by daily monitoring through a Kaizen board and performance indicators. The reported improvements across key processes reached approximately 11%.

A broader adaptation of Lean Production System principles to after-sales services is proposed in Ref. [31], drawing on the VDI 2870 framework. The authors emphasize process mapping, waste elimination through standardisation, preventive maintenance planning, and continuous improvement supported by customer feedback and structured problem analysis.

Finally [32], presents a longitudinal case study of a U.S. collision repair workshop implementing LSS practices, including 5S, visual management, Kaizen events, standardised work kits, and customer relationship management systems. Over a five-year period, the company achieved substantial performance improvements in operational efficiency and financial outcomes.

Collectively, these studies demonstrate that Lean and Six Sigma tools such as VOC, VSM, 5S, Kaizen, poka-yoke, SIPOC, Kanban, and standardisation can enhance process performance, reduce defects and waste, and improve customer satisfaction in automotive workshop contexts. The improvements reported are largely attributable to systematic process redesign and operational reorganisation. As a result, there is a significant increase in productivity and invoicing, as well as a notable improvement in customer satisfaction.

However, a critical gap remains in the literature: despite the extensive body of research on Lean and Six Sigma in manufacturing and general service industries [33–40], particularly the integration of workshop operations with automotive insurance processes. Few

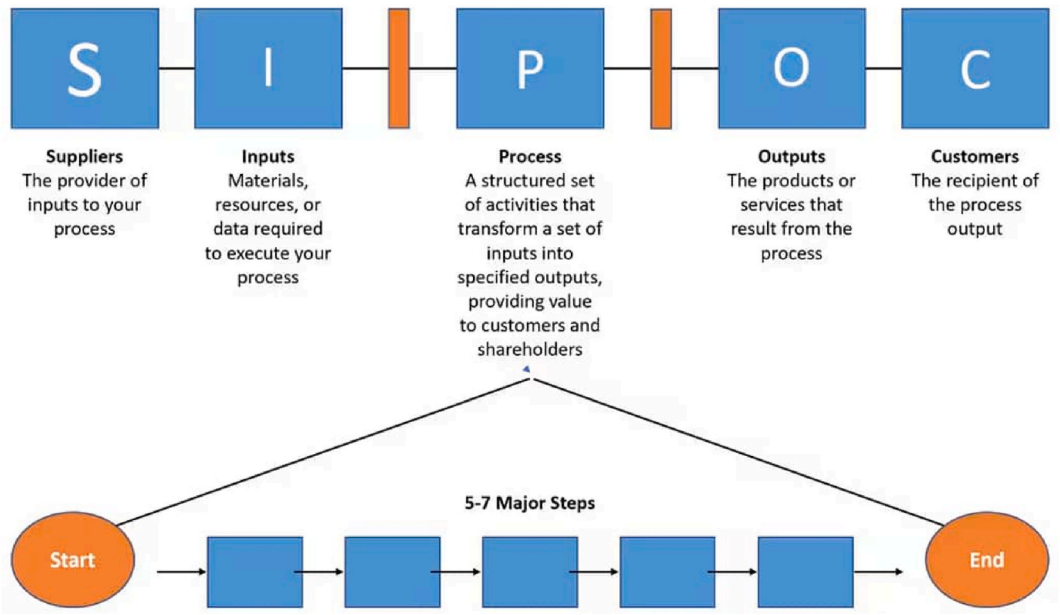


Fig. 2. – Representation of the SIPOC model.

studies examine how process improvement methodologies can be applied across organisational boundaries to align repair operations with claims management, cost control, and service expectations. This gap suggests the need for further empirical research that develops and evaluates sector-specific improvement frameworks capable of supporting data-driven coordination between repair and insurance workflows.

Recent contributions further reinforce the relevance of Lean and Six Sigma in service-intensive contexts, including automotive and insurance-related operations. However, these studies predominantly emphasize performance improvement through the application of established methodologies such as DMAIC, VSM, and KPI-driven monitoring frameworks. While effective, such approaches often rely on structured data availability, predefined performance indicators, and a certain level of methodological expertise. As a result, they provide limited guidance on how to design integrated, low-complexity, and operationally accessible models that can be readily applied in high-variability service environments involving multiple stakeholders. This highlights an important gap in the literature, namely the need for simplified and integrated process improvement frameworks that bridge methodological rigor with practical usability—an aspect that the proposed IMSV model seeks to address.

2.3. Hybrid SIPOC models

Integrated frameworks and models involving Lean Six Sigma have been proposed often in the literature [33]. Several authors provide a comprehensive overview of the application of the SIPOC framework integrated with other models across various domains, highlighting its versatility in driving process improvement, data-driven decision making, and quality assurance. In Ref. [41] the

Table 1
– Synthesis of the representative SIPOC-based models discussed in the literature against IMSV.

Framework	Core Integration	Primary Objective	Methodological Structure	Sector/Context	Key Limitation Addressed by IMSV	Refs.
SIPOC–OI (Open Innovation)	SIPOC + Open Innovation principles	Enhance knowledge acquisition and innovation capacity	Conceptual integration; no embedded process map	Supply chains	Focuses on knowledge flows, not operational simplification	[44]
Circular SIPOC	SIPOC + Circular Economy logic	Identify CE practices in closed-loop supply chains	SIPOC adapted conceptually; supported by qualitative analysis	Manufacturing supply chains	Strategic-level mapping; limited operational detail	[43]
ML-SIPOC	SIPOC + Machine Learning pipeline	Ensure data quality and structure for ML projects	SIPOC extended analytically for data readiness	Manufacturing/ data-driven projects	Data-centric; not designed for workload or process reduction	[42]
SIPOC-PRME (Responsible Management Education)	SIPOC + UN Principles for Responsible Management Education & SDGs	Accelerate SDGs via curriculum design and program management for behavioral change	SIPOC conceptually applied to educational program lifecycle with QA emphasis	Higher education/ program management	Focuses on pedagogical design and stakeholder engagement, not operational process efficiency	[45]
SIPOC + Flowchart + IDEF0	SIPOC + Flowcharts + IDEF0 modeling	Facilitate conceptual modeling for simulation projects	Sequential application of three tools; flowchart provides structure, IDEF0 adds functional detail	Manufacturing/ simulation projects	Multiple-tool approach creates redundancy; IMSV integrates equivalent detail in a single model	[48]
SIPOC–QA	SIPOC + Quality Assurance system	Enhance programme management and QA	Matrix-based conceptual framework linking SIPOC with QA dimensions	Higher education	Managerial and evaluative; no operational process integration or waste elimination	[47]
SIPOC-PI (Performance Indicators)	SIPOC + Financial indicators + BSC + QCD	Develop comprehensive performance indicators across organizational hierarchies	SIPOC as process analysis framework; combined with existing PI models (BSC, QCD, financial)	Cross-sectoral/ performance management	Emphasizes measurement and KPIs; does not address operational simplification or workload distribution	[49]
SIPOC + CATWOE	SIPOC + Soft Systems Methodology (SSM) element	Enrich stakeholder and worldview analysis in process definition	SIPOC complemented by CATWOE (Customers, Actors, Transformation, Worldview, Owner, Environment) for conceptual modeling	Education (teaching/ learning processes)	Emphasizes conceptual clarity and stakeholder roles, but does not operationalize workload or responsibility allocation	[46]
SIPOC (Traditional)	Standalone process-mapping tool	High-level process identification (suppliers, inputs, process, outputs, customers)	Linear flow diagram; primarily conceptual	Cross-sectoral	Lacks analytical depth; requires pairing with other tools for detailed improvement	[50]
IMSV (this study)	SIPOC + service-adapted VSM (Makigami-like)	Process reduction, responsibility rebalancing, simplicity	Fully integrated single model; no redundancy between tools	Tertiary/service sector	Addresses duplication, variability, and accessibility simultaneously	-

authors introduce a new waste classification model specifically for IT organizations, through the integration of SIPOC with process flowchart developed through a case study at “medium-sized” IT department named ORGUS. This tailored approach to lean implementation emphasizes the importance of understanding the unique context and environment of the organization, rather than simply imitating practices from other industries. In Ref. [42] the authors propose a machine learning ML-SIPOC methodology, which extends the traditional SIPOC analysis to systematically establish a robust and high-quality data foundation for data-driven projects in the manufacturing sector. This structured approach addressed the challenges of diverse and complex data sources, enabling effective collaboration between domain experts and data scientists. Another perspective was explored in Ref. [43] through the implementation of circular economy practices across closed-loop supply chains, using the "circular SIPOC" tool to identify a comprehensive set of unique and standard practices. Here, the authors employ a circular SIPOC chart, combined with institutional theory, is utilized to identify CE techniques within the three manufacturing closed-loop supply chain of the United Arab Emirates (UAE), with support from thematic analysis. Another study [44] proposed a SIPOC-OI framework, which integrates SIPOC with open innovation (OI) principles to enhance knowledge management and innovation capacity within supply chains. The proposed tool aims to facilitate the effective identification, acquisition, and utilization of external knowledge sources to drive innovation. The authors in Ref. [45] explored the integration of SIPOC into responsible program management for the acceleration of Sustainable Development Goals (SDGs). It emphasizes the need for systematic methods, such as SIPOC and Six Sigma's DMAIC process, to ensure program success, particularly in creative art-related industries. Even in education SIPOC can be integrated with other models, as shown in Ref. [46] in which a comprehensive analysis of university teaching and learning processes was performed, utilizing the SIPOC model and Checkland's CATWOE mnemonic to understand the various roles of students and instructors. It highlights the complexity of the educational ecosystem and the need for universities to streamline the linkages between processes. Also, in Ref. [47] the authors discuss the integration of SIPOC into program management for quality assurance in higher education, proposing a QA model that combines Six Sigma principles with elements tailored for the education sector, emphasizing the importance of systematic planning, continuous improvement, and social responsibility. The combined use of SIPOC, flowcharts, and IDEF0 modelling techniques to develop the conceptual model for a simulation project, facilitating the efficient creation of the computational model, is proposed in Ref. [48]. The authors in Ref. [49] employ a systematic approach to develop performance indicators (PIs) for organizations or processes. SIPOC is integrated with other existing models, such as financial indicators, Balanced Scorecard (BSC), and traditional QCD (quality, cost, delivery), to provide a more comprehensive approach to performance measurement. This tool is utilized to analyze processes comprehensively, allowing for a structured understanding of how different elements interact within an organization. This systematic approach ensures that all hierarchical levels of processes are considered, from top management to operational staff.

SIPOC is a versatile tool that can be effectively integrated with various models to enhance process analysis and performance measurement. Its application across diverse sectors, including healthcare [50] and education, demonstrates its adaptability and effectiveness in driving process improvements. Despite its potential, research on SIPOC's integration with other frameworks remains limited. These studies showcase the versatility and effectiveness of the SIPOC framework in driving process improvement, data-driven decision making, innovation, and quality assurance across various industries, including IT, manufacturing, supply chains, and higher education. A synthesis of the representative SIPOC-based models discussed in the literature against IMSV can be seen in Table 1.

The studies highlight the importance of tailoring the SIPOC approach to the unique contexts and challenges faced by organizations, underscoring the need for a systematic and contextual understanding of the processes and stakeholders involved. This comparison demonstrates that IMSV does not merely “add” another analytical layer to SIPOC, but instead structurally integrates SIPOC and VSM into a single operational artifact, eliminating the duplication typically observed when the tools are applied sequentially. Unlike earlier hybrids, IMSV embeds the VSM directly within the SIPOC “Process” field, centralizing all critical information (suppliers, inputs, activities, actors, value classification, and improvements) in one visual and collaborative model.

This design choice directly addresses a methodological gap in the literature: the absence of a simple, non-redundant, and service-oriented integration that can be effectively used by multidisciplinary teams without advanced Lean Six Sigma expertise. The previously mentioned approaches preserve SIPOC as the central organizing structure and primarily aim to enhance diagnostic or conceptual capabilities: knowledge flows, data readiness, or sustainability practices, rather than operational process redesign. While IMSV departs from these approaches by repositioning SIPOC as an information-structuring layer embedded within a value-stream-oriented improvement framework.

This design prioritizes simplicity, accessibility, and collaborative usability in service environments, which may involve a trade-off with the analytical depth or domain-specific specialization offered by some existing frameworks. This design choice addresses a gap not covered by prior SIPOC hybrids, which largely remain analytical frameworks rather than hands-on improvement models.

Beyond this conceptual distinction, the contribution of IMSV is also operationally demonstrated in the present study. Unlike prior SIPOC-based hybrid frameworks, which are predominantly proposed at a conceptual or analytical level, IMSV is implemented in a real service environment, where its integrated structure directly supports process redesign. The case study shows how the unified model enables the identification, consolidation, and elimination of activities within a single framework, avoiding the fragmentation typically associated with sequential tool application.

As such, while the limited research in this area highlights the need for further exploration of SIPOC integrations, the present study contributes by moving beyond predominantly conceptual approaches toward an empirically demonstrated, operational model. Nevertheless, further research is encouraged to extend and validate the applicability of IMSV across different service contexts and organizational settings.

3. Integrated SIPOC-VSM model (IMSV)

In order to improve production processes and consequently increase productivity, Lean tools such as the VSM are usually used. This tool can map out the entire production process from raw materials to delivery to the end customer, compiling all the activities. In the case of services, this task can be considerably more complicated due to their variability. When improving procedures in service industries, it is necessary to use a different type of VSM, similar to Makigami [17], which allows it to better deal with the variability present in the tertiary sector.

The VSM rarely is applied in conjunction with another Six Sigma tool SIPOC [51]. The purpose of SIPOC is to collect and organise the information needed to correctly develop VSM and other tools. In one of the 5 fields in which this information is organised, a small-scale process map is drawn up, marking key points in the process. This allows the most relevant information to be recorded in this tool. However, the information generated by the consecutive application of these models is somewhat repeated, in other words, the information that was described in the SIPOC model was later presented in the VSM. For this reason, this approach presents some evidence of procedure repetition. As a result, the opportunity to create a combined model that would take into account the strengths of each of the previously mentioned tools (VSM and SIPOC) emerged. It also allows information to be centralised in a single integrated model, called IMSV.

The main function of this model would be to reduce and reorganise processes and their responsibilities, making the production cycle more efficient and simpler. IMSV will be beneficial in reducing the number of processes compared to the initial production cycle. This process is composed of a number of activities that may or may not add value to customers. These activities, when exposed to the model in question, can be reorganised, improved, replaced or even eliminated in order to reduce the number of repetitions and inefficiencies. It is crucial that this process is drawn up by a multidisciplinary team that provides important inputs into the process in order to obtain reliable results. This will be an important detail for setting up all the current points of the process and its future objectives.

3.1. Application of IMSV

To construct this model, one must first critically engage with the operational workflow via direct observation and stakeholder interrogation. In this case, there is a need to apply a very relevant technique from the Kaizen methodology called "Gemba Walks". This term is often associated with the expression "going into the field" and "seeing with your own eyes", as it refers to direct contact with the day-to-day life and processes of an organisation. As mentioned in Refs. [52–54], the "Gemba Walk" is one of the best practices used to identify problems and communicate with other team members about any suggestions for improvement that may arise.

As the proposed IMSV model is grounded in a qualitative–process improvement paradigm rather than a data-driven optimization or predictive framework, traditional notions of parameter selection and numerical data preprocessing are not directly applicable. The primary "inputs" to the model consist of operational activities, process sequences, actor assignments, and value classifications, which were systematically identified through direct observation (Gemba walks), semi-structured interviews, and internal process documentation. These elements were validated through triangulation with process owners and operational staff to ensure consistency and accuracy prior to analysis and redesign.

From a methodological perspective, the application of IMSV in this study is guided by a set of underlying assumptions consistent with qualitative process improvement research. First, the study assumes a high-variability service environment in which stable and reliable quantitative performance metrics (e.g., cycle time or defect rates) are not consistently available. Second, it adopts an activity-based perspective as the primary unit of analysis, considering activities, actor roles, and process sequences as the most meaningful elements for identifying inefficiencies. Third, the data collection process relies on qualitative and triangulated sources, including direct observation, semi-structured interviews, and internal documentation, with validation by process stakeholders. Finally, the integration of SIPOC and a service-adapted VSM into a single model is based on the assumption that reducing fragmentation between tools improves usability, transparency, and collaborative process analysis in practice.

The first step in the development of IMSV is to choose the appropriate framework for its organisation. It can be developed in

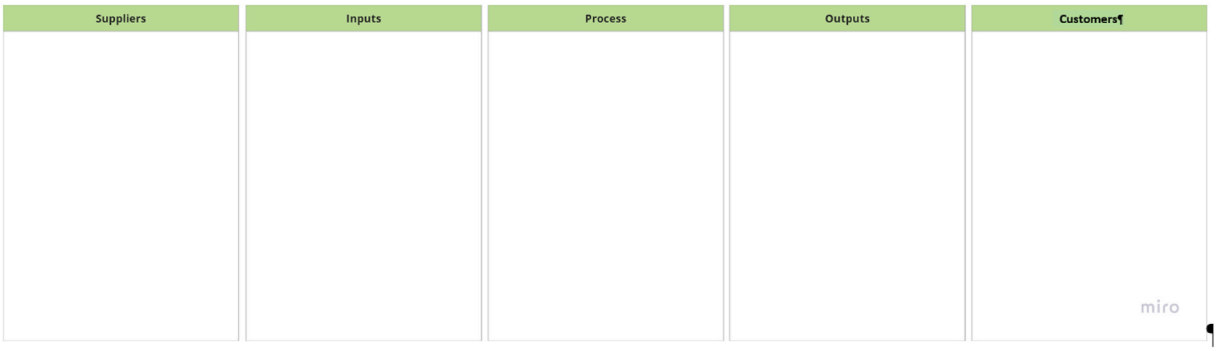


Fig. 3. – Beginning the construction of the IMSV.

physical or digital format. In physical format, there are two options:

1. Use of a magnetic whiteboard on which notes can be made using different coloured pens.
2. Using a piece of paper placed on the wall, where you can stick post-its, sticky notes and other types of paper to develop the model in question.

These approaches are quicker and easier to perform and allow easy visualisation by all the involved parties. However, it is possible to develop this model digitally, with the help of various software packages. Free software that can be accessed by multiple parties is ideal for this purpose. This may be the right option for the remote development of this tool, in which the various team members meet via video conference and other forms of contact.

The traditional SIPOC tool format should be outlined in the software, with a box created for each element as shown in Fig. 3 (Suppliers, Inputs, Processes, Outputs and Customers).

Then all the information must be added to serve as input for the VSM. In other words, the information described in the Suppliers, Inputs, Outputs and Customers tables will then be used to develop the Process table. In the traditional approach, this table is filled in with a very simple flowchart that only describes the key processes.

The boards should be filled out in order and with the participation of all members, as shown in Fig. 4.

The Suppliers and Inputs tables should contain information on all the process needs to function, answering the questions "Who supplies and what is supplied?". The Outputs and Customers tables, on the other hand, will be composed of objective information about the process, answering the questions "What comes out of the process and to whom?".

With the previous information complete, the VSM can be developed. In the first instance, it is necessary to outline the main key processes of the overall process. These are used to create a linear process diagram, as shown in Fig. 5.

There is also a need to create a space where activities can be introduced which, although they are not directly part of the main process, they should be referenced (represented in Fig. 5 as "Other indirect processes"). These should be inserted because they can sometimes influence the main processes and these may also need to be reorganised.

In a next step, you can start filling in the key processes and the other indirect processes with the activities that make them up, as shown in Fig. 6.

This activity would be described with two essential details. One of the important details to record is the individual actors involved in a particular activity, represented in Fig. 6 by the green circles. To make things easier in terms of visual presentation, the actors are designated by abbreviations, which are recorded in a legend. It is also necessary to designate the type of value for each activity, this is designated in Fig. 6 with a coloured square according to the type of value it has, as shown in Fig. 7.

Once the VSM has been completed, it will be possible to visualise the tool in its current state, as shown in Fig. 8.

Given the above, the number of processes that each actor performs remains to be counted. In other words, if an activity is carried out by 3 people, that activity counts for 3 activities, and so on. In the end, the value of the activities relating to the overall process is summed up. This operation is carried out in this way so that the repetition of activities can be accounted for. At this stage, improvements and reorganisations of process activities are made in order to achieve greater efficiency. There are two ways of eliminating waste using this tool. One is to reduce the number of activities performed in the overall process. There may be activities that are performed by two or more collators, so if we can establish that the activity is only done by one, we reduce the waste of duplication. Furthermore, with the collaboration of the team, it may be possible to recognise the obsolescence of certain procedural activities and identify creative and innovative alternatives that will, above all, reduce the time it takes to carry them out. These improvements can be aided with the help of Lean and Six Sigma methodologies, using the tools Kanban, Poke-Yoke, Visual Management, Statistical Process Control (SPC), SMED, Andons, and others. In the event that one of these tools is applied, they must be identified in the VSM with the Kaizen Burst symbol as shown in Fig. 9. With the appropriate indication of which tool or improvement will be developed in the given activity or process.

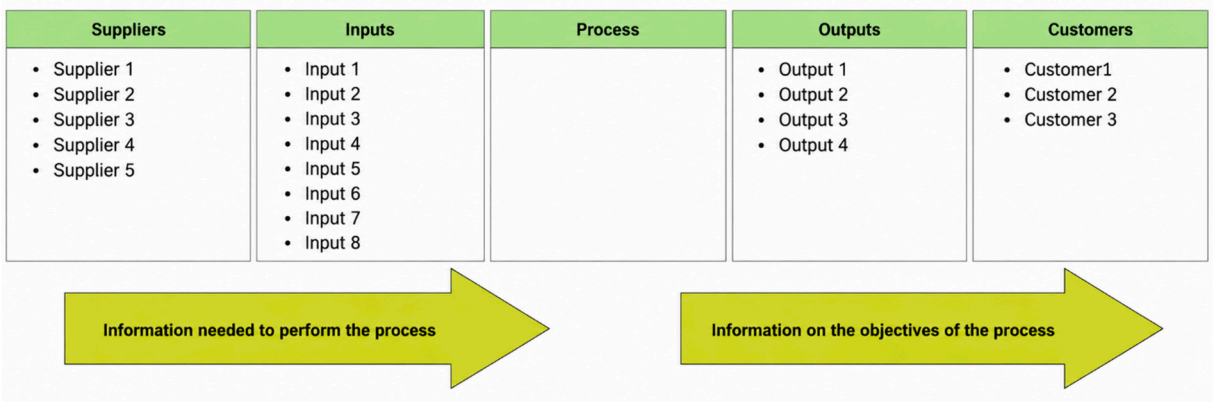


Fig. 4. First steps filling IMSV.



Fig. 5. Key processes of VSM.



Fig. 6. Current state VSM.

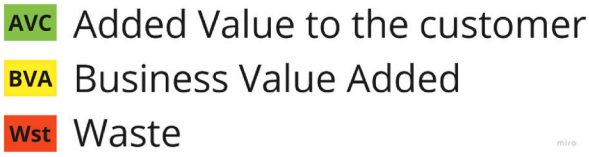


Fig. 7. Values of the activities.

In the final phase, the results achieved by applying this model can be recorded, if necessary. These include the reduction of processes between the VSM of the current state and the VSM of the future state. And also the possible process/activity time reductions that were achieved with the Kaizen Bursts. There is also the possibility of relating other types of process/activity improvements that are not quantitative. Such as improvements in customer service, the appearance of a workspace, worker confidence and other related qualitative characteristics.

4. Case study

The aim of this project was to create and apply the IMSV in order to improve the processes of CAA's collision department. Subsequently, the model developed, will be described in relation to the case study in question, carried out in CAA's collision workshop. This model will serve to reduce the processes and activities carried out by the department's team and also apply other LSS improvements to certain activities. This will enable not only the processes to be reorganised, but also the activities inherent to it. With this methodology, it will be possible to continuously improve the company's processes, allowing it to work more effectively and efficiently in the future.

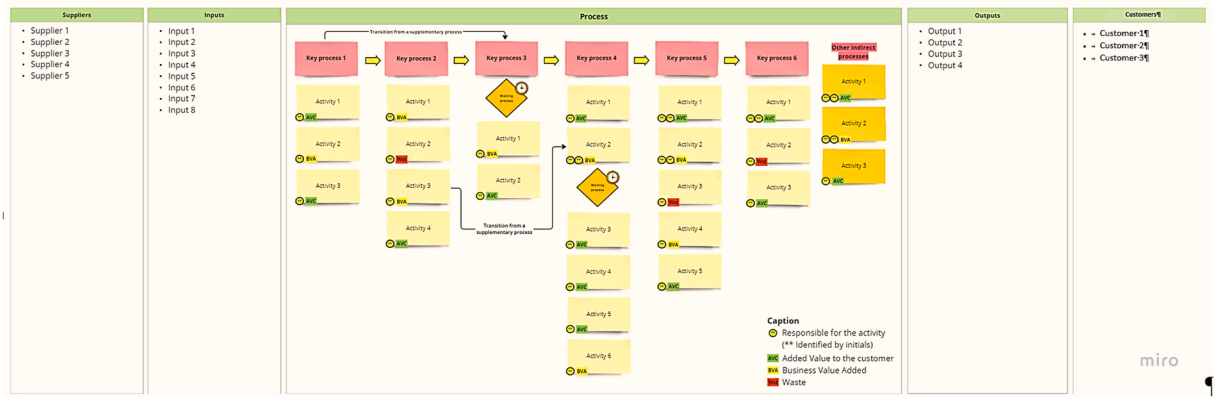


Fig. 8. Current state IMSV.

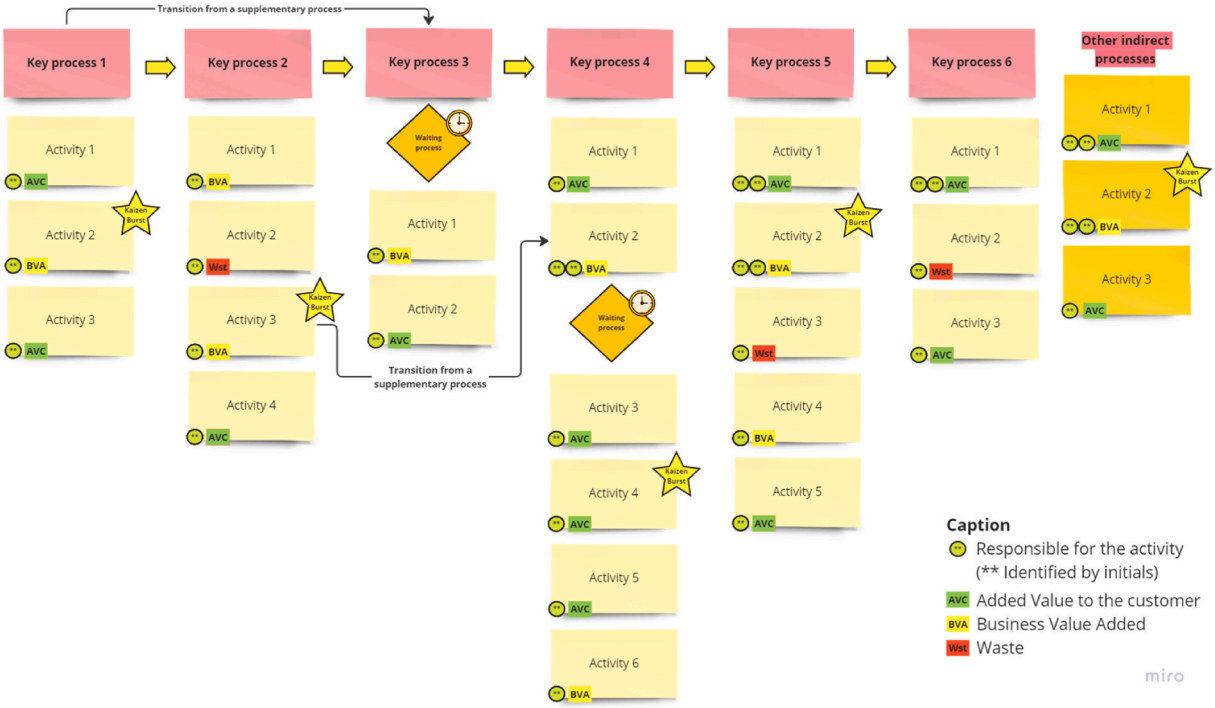


Fig. 9. Current state VSM with Kaizen Bursts.

4.1. Presentation of the company

Nowadays, the Salvador Caetano Group is an economic group with companies in various business areas that is highly expressive in Portugal. Its history with Toyota began in 1968, when its founder Salvador Fernandes Caetano signed the contract to be the official Toyota importer and distributor in Portugal. Caetano Auto, one of the group's companies, is responsible for selling new and used vehicles with the appropriate financing services and mechanical and collision repair services. Caetano Auto's collision services also cover 24 other car brands.

The company involved in this case study is Caetano Auto in Alfragide. It provides automobile repair services in the areas of mechanics and collision. This study will focus on CAA's collision department. This is responsible for the repair of sheet metal and paintwork on multi-brand vehicles and Toyota in particular. In total, there are around 18 collision centres in Portugal. The CAA is very small, especially in terms of infrastructure (Layout in Appendix 1), human resources and materials. However, it accounts for around 4% of the CAA's national revenues. And in the annual turnover ranking, it ranks 11th out of the other 18 concessions. The business volume is 85% for protocol clients (74% Insurances and 11% Fleet Managers) and 15% for individuals and reconditioning. At CAA, turnover is distributed with around 63% of annual turnover for mechanics, 33% for collision and the other 4% for glass substitution

services.

4.2. Integrated SIPOC-VSM model (IMSV)

The purpose of IMSV, applied to the CAA workshop, is to improve the procedures related to the collision workshop during its repair production process. Repairs can come from a variety of sources, including insurance claims, fleet management or private customers. This model reorganises and standardises processes and the individuals responsible for them in order to improve production cycles. In other words, reducing the number of processes carried out as well as proposing other improvements that can reduce workers' activity time, promoting a higher level of productivity. This model will make it possible to identify what does or does not add value to the client, how the process is triggered, who is involved in the process, whether there are overlapping procedures between individuals and how the process can be improved so that its efficiency also increases.

The case study was conducted over several months and covered the full operational cycle of the collision workshop. Data collection combined direct non-participant observation through Gemba walks, semi-structured interviews, internal process documentation, and regular project development and validation meetings. Participants were purposively selected based on their direct involvement in,

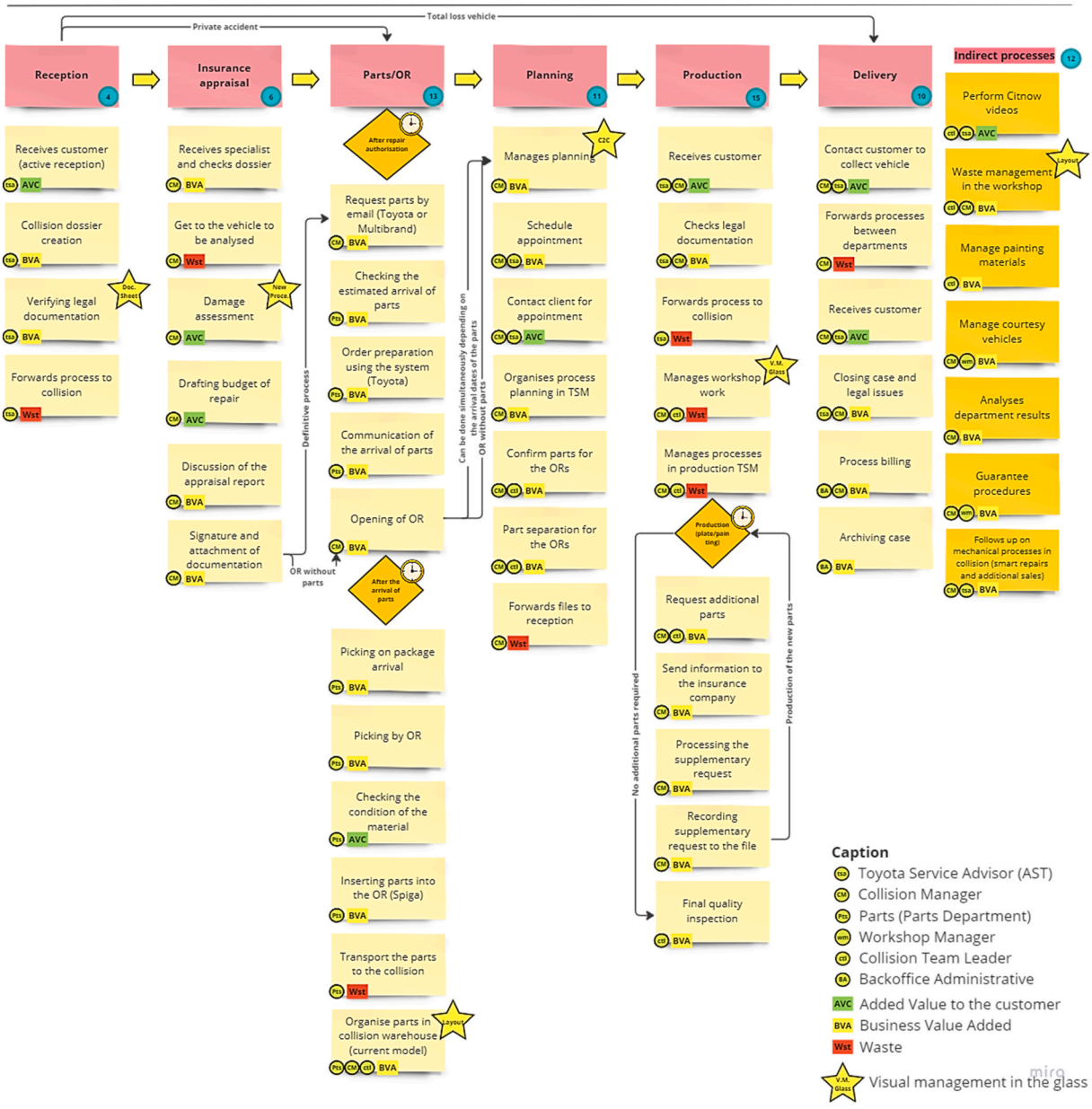


Fig. 10. Current state VSM of the case study.

responsibility for, or operational knowledge of the collision repair process. The participants included the National Collision Director, the Workshop Manager, the Collision Team Manager, and operational members of the collision team. The total number of individuals involved in the broader operational team was not systematically recorded as a participant count because the IMSV development involved the wider collision team at different stages of the process. Similarly, the exact number of interviews and validation meetings was not systematically recorded during the original case study. Rather than retrospectively estimating these numbers, these limitations are explicitly acknowledged. The project involved regular weekly development meetings, complemented by direct Gemba observations and discussions during required and daily Kaizen meetings.

Activity identification and mapping followed established Lean case-study practices [55,56]. Activities were included when they were recurrent, operationally relevant, and explicitly validated by at least one process owner and one operational actor. The combination of direct observation, semi-structured interviews, internal documentation, and stakeholder validation provided methodological triangulation and helped reduce subjectivity in the mapping and redesign process, in line with methodological guidance for applied Lean Six Sigma research [57].

Initially, it was important to learn more about the process. Keeping in touch with the day-to-day life of the team members (Gemba Walk), with the activity, its difficulties, the various stages of the production cycle and, in short, all the procedures to be followed in order to provide a good service to the customer. At first, as a way of organizing the knowledge acquired to date, it was necessary to draw up a process map as shown in appendix 2. This allowed the process to be monitored in a more general state, but where the details of the process could be visualised. Subsequently, all the activities carried out by each of the managers had to be compiled. In this way, it was possible to identify redundant activities, allowing them to be reorganised, improving the efficiency of the service.

The IMSV was developed using the MIRO software. Initially, the first 6 key processes were defined, designated by the pink rectangles as shown in Fig. 10. These comprehensively represent the processes that compose the repair of an insurance case at the CAA. As well as the activities indirect to the main activity, as can be seen in the "Indirect Processes" column. Next, with a view to outlining the overall process observed in CAA's collision repair shops, it would be necessary to fill in each key process with its activities (Fig. 10).

It is necessary at this stage to detail the entire process so that no important activity is left out, which is why it is important that this is performed with the help of the various team members involved in the repair process. It was also necessary to point out all the types of processes that can occur, these differences are manifested in the sequence of activities/processes. In the model under study, these were signalled by arrows, as can be seen in Fig. 10. These arrows lead a certain condition to the next step in its process. These could be insurance cases where only the individual is invoiced without informing the insurer, vehicles that are assessed as a total loss, definitive expert processes, labour-only repair processes and processes where new parts need to be inserted halfway through the production process. As these procedures were consolidated, opportunities for improvement were identified, structured and discussed with the workshop managers. These can be seen in Fig. 10 by the yellow stars (Kaizen Bursts) which inside indicate the improvement applied.

Ideally, the improvements should be referenced so that in the continuous use of the model there is always a focus on the status of their application. These improvements should not be neglected until implemented, which can be accomplished using a PDCA cycle. Subsequently, the individuals who perform each activity within each key process were designated, so that the reduced processes could then be counted. The number of activities can be seen in Fig. 10 by the blue circular shapes. Lastly, each activity was classified

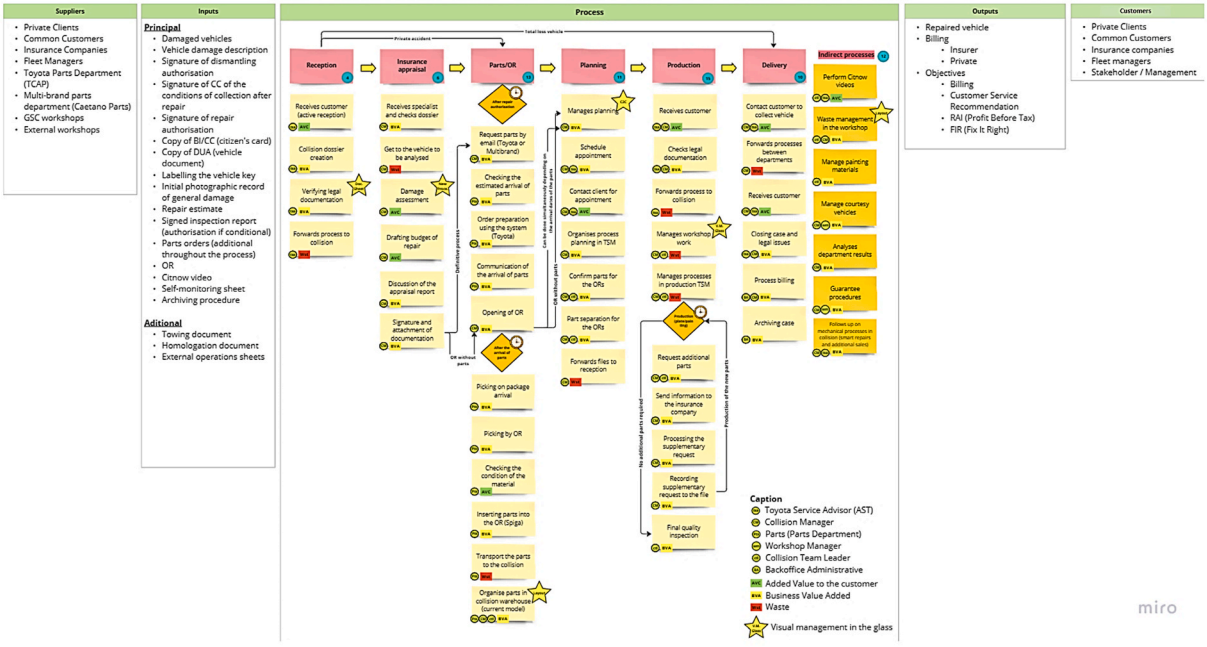


Fig. 11. Current state IMSV of the case study.

according to its contribution to the process. Three categories were adopted: Customer Value Added (AVC), Business Value Added (BVA), and Waste (Wst). These classifications are present in all the activities by small rectangles, as can be seen in Fig. 10.

Activities were classified according to Lean value analysis principles. Customer Value Added (AVC) activities were defined as those directly contributing to the value of the service delivered to the customer. Business Value Added (BVA) activities were those that do not directly create customer value but are necessary for operational, organizational, or regulatory reasons. Activities that neither created customer value nor were operationally required were classified as Waste (Wst) and therefore considered candidates for elimination, simplification, or redesign. To reduce subjectivity, all classifications were discussed and validated with the workshop management and the operational staff involved in the mapped processes.

Finally, the result of the current state of the process can be seen in Fig. 11.

Following this, and with the cooperation of all the available team members, it was possible to reorganise responsibilities in order to reduce the number of activities. This reduction was drawn up together with the intern supervisor who holds the position of national collision director at CAA. These meetings served to establish the operational objective for the CAA's activity, as well as to present and validate the proposals for improvement that resulted from the application of the IMSV. Once the guidelines and objectives had been defined, meetings were then held with the workshop manager and the CAA collision team manager, who would approve and put into practice the improvements proposed. These were then discussed with the workers in a required meeting or in a daily Kaizen meeting. Once all parties had approved, the improvements were implemented, monitored and recorded in the future state model. This way, the whole procedure would become a standardised process. The result of the future VSM can be seen in Fig. 12.

By comparing Fig. 11 (current state IMSV) and 12 (future state IMSV), it can be analysed that improving and reducing the procedures carried out will considerably improve the repair process in the CAA's collision workshop. This document will also serve as a reference guide for any employee who needs to check the procedure to be adopted, will serve to monitor the application of the various proposed improvements and will also serve as a record of the current state. In other words, in the long term, if the procedure to be adopted needs to be updated again, this can be done using the IMSV of the future state shown in Fig. 12. However, this will then be considered the current VSM, and the whole process of applying the model can be repeated as a cycle again, promoting the continuous improvement of the process.

The comparison between the current-state and future-state IMSV models reveals that the primary efficiency gains were achieved through the deliberate elimination of non-value-added and duplicate activities and through the strategic redistribution of responsibilities across key operational roles. Activities were removed when they were found to contribute no direct customer value, duplicate existing controls, or exist solely to compensate for upstream process deficiencies. In parallel, responsibilities were reassigned to reduce unnecessary handoffs, shorten decision cycles, and strengthen process ownership, particularly at critical interfaces between technical, administrative, and customer-facing functions. This restructuring not only reduced coordination delays and error propagation but also produced a more balanced workload distribution, enabling faster throughput and improved service reliability. The resulting process architecture reflects a shift from fragmented activity execution toward integrated, flow-oriented operations, consistent with core Lean principles of waste elimination, role clarity, and continuous improvement.

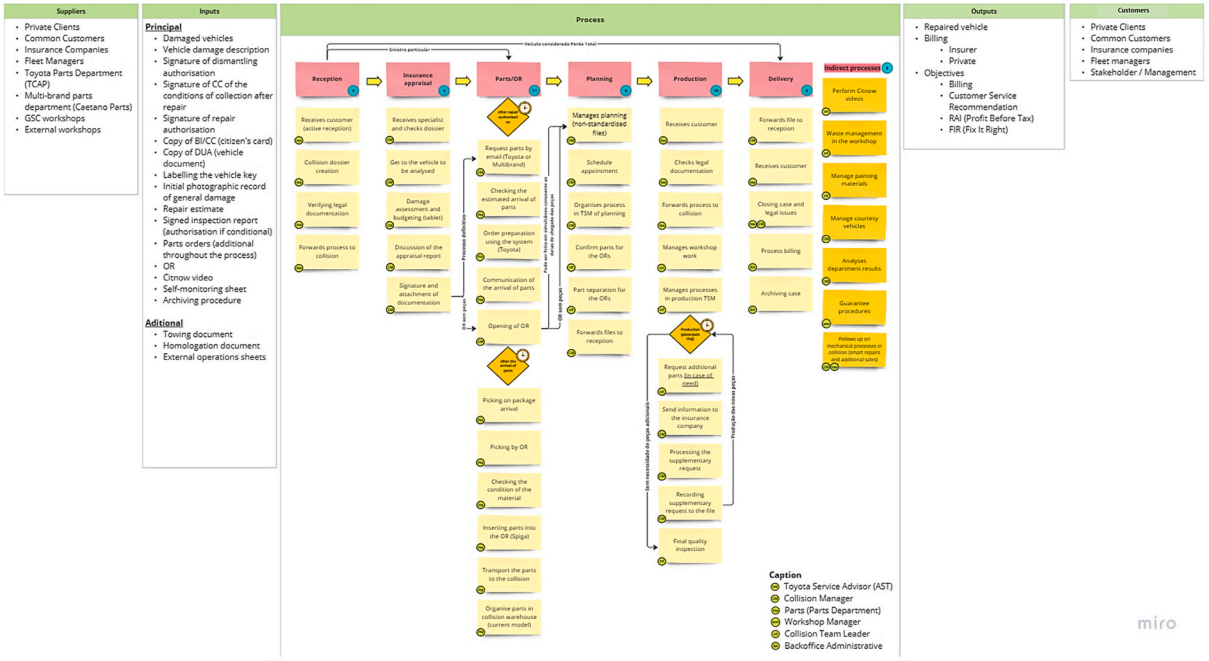


Fig. 12. Future state IMSV of the case study.

5. Discussion and results of IMSV

5.1. Improvement results by key processes

Although the model in this study defines key processes at an early stage in its application, it is possible to calculate the improvement achieved in each of these processes. These are highlighted because they are of great importance in the overall procedure. Fig. 13 shows the improvement results by key process.

Fig. 13 shows that the arithmetic mean reduction across the seven key processes is 26.9% (approximately 27%). The largest reduction was observed in Planning, with a 45.5% decrease in the number of activities. Production, Delivery, and Other indirect processes also showed substantial reductions of 33.3%, 40.0%, and 33.3%, respectively. In contrast, Reception showed no reduction, while Insurance Appraisal and Parts/OR decreased by 16.7% and 15.4%, respectively. These results are very positive due to the significant reduction in each of the key processes. Particularly in Parts/OR, Planning, Production, Delivery and Other indirect processes, where it can be seen that the number of activities was higher at the beginning of the application of this model.

To provide a more detailed analysis of the improvement achieved across the key processes, Table 2 summarises the number of activities identified in the current and future states, together with the corresponding percentage reduction for each process. This analysis allows the improvements to be examined both individually, at the level of each key process, and collectively, based on the total number of activities. The arithmetic mean refers to the unweighted mean of the seven individual key-process reductions, whereas the total reduction is calculated from the aggregated activity counts.

5.2. Improvement results by the person responsible in charge

The method of counting the activities present in each of the key processes is to count each activity carried out by each responsible individual. In other words, if an activity is carried out by just 1 individual, the key process only accounts for 1 procedure, if it is carried out by 3 individuals, it now accounts for 3. For the same reason, it is possible to assess how the activities are distributed among each individual. This makes it possible to assess the reductions inherent in them, as can be seen in Fig. 14.

Analysing the results, the arithmetic mean reduction across the six responsible actors is 22.1% (approximately 22%). The collision manager showed a reduction of 44.1%, decreasing from 34 to 19 assigned activities. The Toyota service advisor showed a reduction of 28.6%, decreasing from 14 to 10 activities, while the workshop manager showed a 50.0% reduction, decreasing from 2 to 1 activity. The administrative Backoffice and parts responsibilities remained unchanged, while the team leader showed a 10.0% reduction. However, the reduction in the workshop manager is less significant due to his limited involvement in the production process. On the other hand, the collision manager and the service advisor show very significant reductions, conveying a sense of balance in the overall process.

5.3. Overall improvement results

In order to demonstrate the total improvement brought by the application of IMSV, it is necessary to generalize the achieved results, which are shown in Fig. 15.

Fig. 15 shows that the total number of identified process activities decreased from 71 in the current-state IMSV to 50 in the future-state IMSV. This corresponds to an absolute reduction of 21 activities and a relative reduction of 29.58% (approximately 30%). This

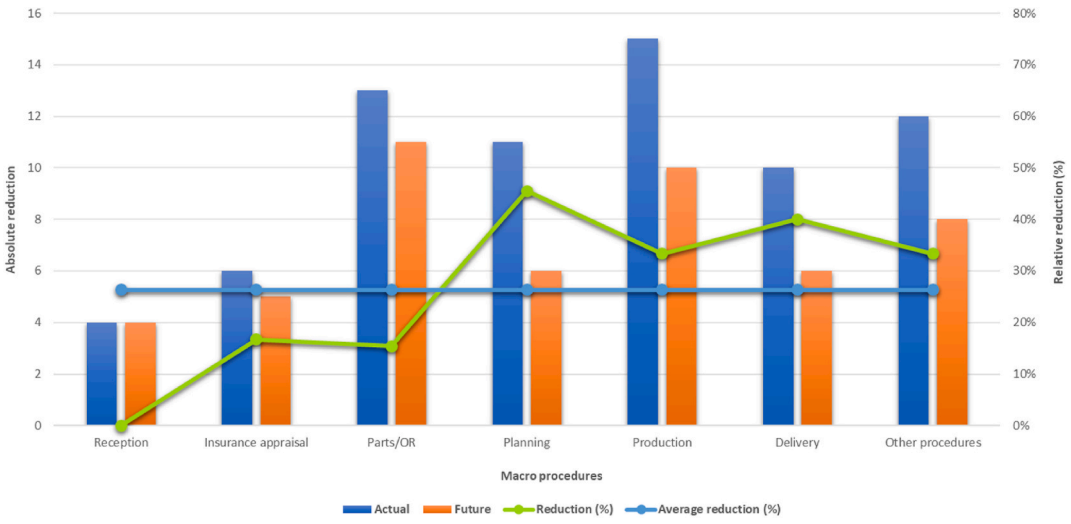


Fig. 13. IMSV results by key process.

Table 2
– Activity reduction by key process in the current and future IMSV states.

Key process	Current state	Future state	Reduction (%)
Reception	4	4	0.0
Insurance appraisal	6	5	16.7
Parts/OR	13	11	15.4
Planning	11	6	45.5
Production	15	10	33.3
Delivery	10	6	40.0
Other indirect processes	12	8	33.3
Total	71	50	29.6
Arithmetic mean of individual process reductions	—	—	26.9

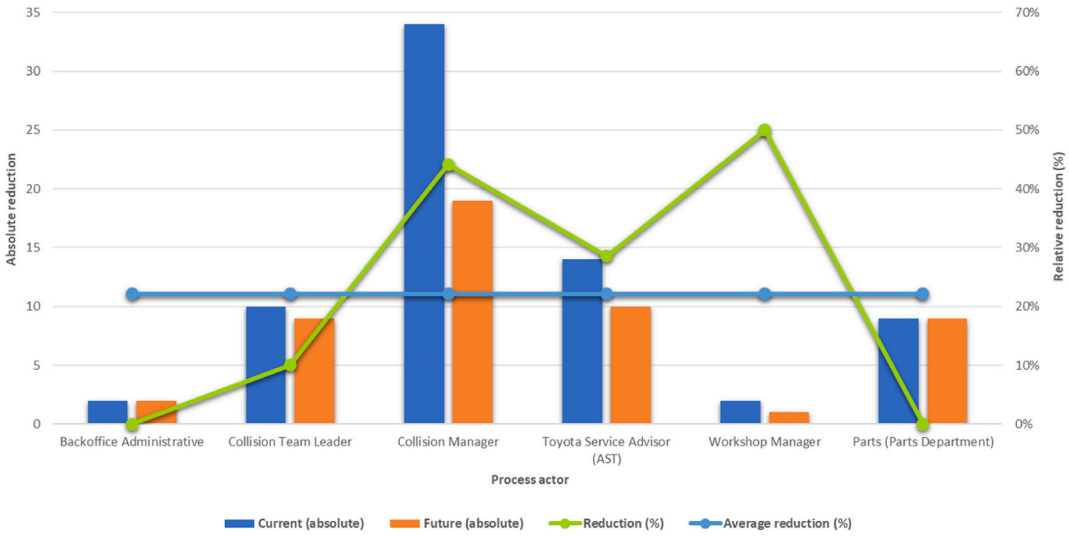


Fig. 14. IMSV results per responsible actor.

result represents the overall reduction across both key and indirect processes and should therefore be distinguished from the arithmetic mean of the individual key-process reductions reported in Section 5.1. This represents the relative reduction in the total number of processes/activities identified between the current-state and future-state IMSV models, rather than to time- or defect-based performance metrics. As illustrated in Fig. 15, the absolute improvement corresponds to the elimination or consolidation of 21 processes

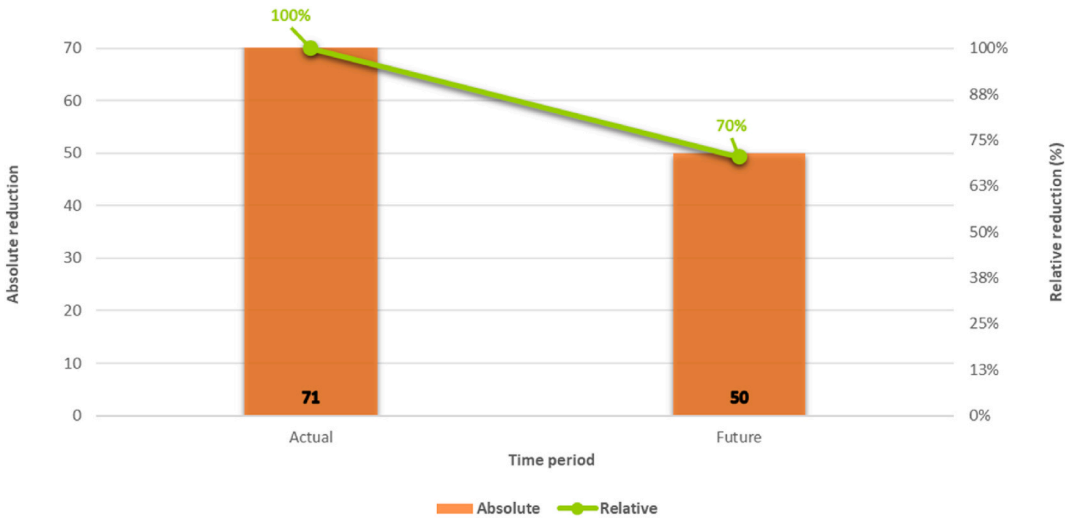


Fig. 15. General IMSV results.

across both key and indirect procedures when transitioning from the current to the future state. In relative terms, this represents an overall reduction in the process of approximately 30%, which can be considered significant in the context of service operations. This reduction reflects a tangible simplification of workflows, a reduction in coordination efforts, and an improvement in service delivery, with a lighter operational burden on the responsible team, in line with established Lean service improvement principles. This dual-perspective measurement approach is consistent with prior Lean service studies that emphasize activity-based and responsibility-based analysis in the absence of stable time or defect data [58].

5.4. Purposes for the application of IMSV

IMSV was created on the principle of process improvement, mainly aimed at the service sector. The aim of this model is to simplify and reduce the number of activities in a given process. One of its special features is that it can improve established processes by identifying and eliminating unnecessary or redundant activities. In this way it is possible to increase the efficiency and effectiveness of the overall process, reducing the time and resources needed to execute it. The process is a significant advance in process management and promises to bring benefits to organizations looking to improve their services.

During the development of the model, it was possible to notice that its flexibility allows for several different applications. For example, adding new procedures to an established process. This allows the services offered by companies to be modified at any time, prioritising the improvement of the effectiveness and efficiency of the overall process. This improvement is achieved due to the detail the model offers in the organisation of the sequence of activities and processes, the organisation of the individuals responsible for each activity, the elimination and reorganisation of waste throughout the process and even the way in which it is possible to highlight improvements in certain activities of each key process. Since the model was developed as a team, it also allows for transversal opinions that have direct contact with the process. This is crucial for maximising the model's capabilities.

Due to the model's remarkable versatility, it is even possible to design a completely new process. This feat becomes conceivable due to the features that the model integrates. Focusing mainly on the organisation of processes and activities, team discussion, the creation of a visual model with the particularities of the procedure and access to the various details in its development. This means that it is possible to create a completely new procedure for a company or organisation in the most efficient and effective way possible. The only difference with the model described in chapters 3 and 4 is that it does not provide a measure of the improvement achieved (future state model).

From a methodological and structural standpoint, IMSV is distinct from the other SIPOC-based hybrid frameworks in three key ways. First, unlike SIPOC-based hybrids that integrate external theories or advanced analytics (e.g., machine learning in ML-SIPOC [42]), IMSV integrates two foundational Lean Six Sigma tools—SIPOC and VSM—at the process-mapping level, creating a single, coherent workflow for current-state and future-state analysis. Second, IMSV introduces a structural modification in the SIPOC "Process" element, replacing linear process descriptions with a VSM-inspired representation adapted from service-oriented variants (e.g., Magikami-type VSM), which is not reported in prior SIPOC integrations In Refs. [41], [48]. Third, IMSV is intentionally designed to minimize technical complexity, contrasting with frameworks such as SIPOC-OI [44] or circular SIPOC [43], which require substantial conceptual or theoretical expertise to implement effectively.

5.5. Internal validation and contextual triangulation

The proposed IMSV was internally validated through its application in the CAA case study and through the triangulation of evidence obtained from multiple stakeholders involved in its development and implementation. It was developed in the specific working context of CAA and with the cooperation of the various teams working within it. Among those involved in the creation and implementation of the model are Caetano Auto's National Aftersales Director, the Caetano Cascais and Oeiras Aftersales Manager, which includes CAA, CAA's Workshop Manager, CAA's Collision Team Manager and the rest of the collision team. The collaboration between these experienced and qualified professionals guarantees the validity and effectiveness of the model developed. This work involved many months of analysis at Gemba, weekly project development meetings, direct contact with the process and the team responsible, as well as access to all the necessary information about the company and the service it offers in the collision department. This collective effort enabled the creation of a robust and effective model, capable of significantly improving existing processes.

The model was applied to one of the company's processes and its improvement effect was realised, as can be seen in the results achieved. These improvements were seen in the general reduction of the processes necessary for production, with a significant reduction in key processes being emphasized. As a result, the overall process has become leaner, reducing the variability that creates instability in the normal operation. By using the IMSV model, it was possible to tackle delays, duplication, unnecessary movement, unclear communication, missed opportunities and mistakes.

Through a comprehensive analysis of various scientific articles, it was observed that continuous improvement and process mapping are topics that are frequently explored in various industries. However, it is notable that most of these studies employ VSM, a tool derived from TPS, which is widely used to visualise and improve the flow of materials and information. Despite the proven effectiveness of VSM in various industries, its application in the service sector is rather limited. Most of the existing studies focus predominantly on manufacturing, where processes are often tangible and measurable.

However, two studies were identified using process mapping techniques as a tool for continuous improvement, not only in the context of an organisation's internal procedures, but also as a means of improving the services provided to customers. One of the studies looked at improving the efficiency of hospital operating rooms, which are costly units and essential for the economic sustainability of healthcare institutions. To achieve this, a comprehensive approach using Lean and Six Sigma methodologies was applied

to an entire area of operating rooms. A multidisciplinary team developed a VSM of the entire surgical process and analysed each stage in three dimensions: personnel, information processing and time. Improvements were implemented in five key areas, resulting in substantial improvements in the punctuality of surgeries, a reduction in cases after 5pm, savings in non-operative time and a reduction in staff overtime. This in turn resulted in significant increases in the profit margin per operation room a day. In conclusion, the Lean and Six Sigma methodologies have proved effective in improving the efficiency of the entire surgical suite, with substantial and financially advantageous benefits. These improvements are replicable in other medical specialities [16]. The other study analysed focuses on improving service at a Toyota dealership. Through value stream mapping, a number of problems were identified, including waiting times, washing processes and service duration. Using the DMAIC methodology and other Lean and Six Sigma tools, the service time for express maintenance was reduced from 120,06 to 64 min, which is an improvement of 53% per service cycle. This improvement in service quality results in customer satisfaction, increases the company's profits and makes it more competitive among its competitors, contributing to the company's future sustainability [59]. The studies mentioned previously prove that process mapping and other LSS improvements are essential management tools for improving efficiency and quality in the service sector. However, it is important to emphasize that process mapping, in particular VSM, was originally developed for the manufacturing industry, therefore creating an added difficulty in adapting this tool to the tertiary sector. This is due to the specific characteristics of services, which often involve human interactions and more variable processes. For this reason, IMSV represents a significant innovation in the area of continuous process improvement, providing a more accessible and flexible approach for companies' and multidisciplinary teams.

After joint validation by analysing the procedures taken to apply the IMSV model, together with the analysis of articles that refer to the basic tools of the IMSV model, it is possible to assess that the model in question is effective in terms of its objective, and, in terms of its effectiveness and applicability.

5.6. Broader societal and policy implications

Beyond its operational contributions, the proposed Integrated SIPOC–VSM Model (IMSV) carries important societal implications for service-intensive sectors such as automotive repair and insurance. In this context, the improvements observed in the case study—particularly the reduction of non-value-added activities, simplification of workflows, and clearer allocation of responsibilities—suggest potential implications for service efficiency, organizational coordination, and operational consistency. These improvements enhance service reliability and reduce operational costs, which can ultimately translate into more affordable and predictable services for customers. Moreover, the clearer role definition and reduced process fragmentation foster healthier working conditions, lower cognitive workload, and improved employee engagement resulting in outcomes that align with broader goals of decent work and sustainable productivity emphasized in contemporary operations management and Lean service research [23–27].

From a policy perspective, the findings of this study are relevant to ongoing efforts aimed at improving productivity and resilience within service-based economies. The automotive after-sales and insurance ecosystems are critical components of national transportation infrastructures, and inefficiencies within these systems generate cascading economic and environmental effects, including increased repair times, higher insurance premiums, resource waste, and avoidable emissions. Thus, providing a low-complexity, data-light improvement framework that can be adopted even by organizations with limited Lean maturity, IMSV supports policy objectives related to service sector modernization, digital and operational transformation, and sustainable industrial competitiveness [60–64]. Its emphasis on transparency, visual management, and continuous improvement also complements regulatory frameworks that promote quality assurance, accountability, and consumer protection.

Finally, IMSV offers a practical mechanism for aligning organizational practice with broader sustainability and governance agendas. Process simplification reduces resource consumption, minimizes unnecessary movement and material handling, and supports more efficient utilization of physical and human capital, thereby contributing to environmental and social sustainability goals. At the same time, the collaborative and participatory nature of IMSV implementation strengthens internal governance structures by promoting cross-functional communication, shared responsibility, and evidence-based decision making. In this sense, IMSV functions not merely as a technical process improvement tool, but as an enabling framework for responsible and resilient service operations, capable of supporting both organizational performance and broader societal well-being.

5.7. Overall synthesis

The novelty of IMSV is most clearly demonstrated in its application domain and intended users. While prior SIPOC integrations have been applied in manufacturing [42], supply chains [43], IT [41], or higher education quality assurance [47], these studies typically target expert-led analyses or strategic-level decision making. IMSV, by contrast, is explicitly conceived as a collaborative, shop-floor-accessible improvement model for service organizations with limited Lean Six Sigma maturity. Its empirical validation in a real-world service workshop shows measurable performance gains – activity reductions, workload balancing, and process simplification – that go beyond conceptual validation and respond directly to the literature's acknowledged scarcity of applied SIPOC-based integrated models in Lean management contexts [33], [49]. We therefore argue that IMSV's contribution lies not in proposing another SIPOC variant, but in offering a pragmatically integrated, service-oriented improvement methodology that bridges a well-documented gap between analytical SIPOC extensions and actionable Lean process redesign.

The IMSV proves its worth by successfully reorganising the processes relating to the CAA's collision workshop. The results obtained through the application of the Integrated SIPOC-VSM Model demonstrate that the primary drivers of improvement were the systematic elimination of non-value-added activities and the redistribution and clarification of process responsibilities. By embedding a service-adapted VSM within the SIPOC structure, IMSV enabled the identification of redundant activities, unnecessary handoffs, and

misaligned responsibilities that are characteristic of high-variability service environments. The observed 30% overall reduction in activities, along with substantial workload balancing across key roles, reflects fundamental Lean Six Sigma principles of waste reduction, flow simplification, and process ownership, confirming the conceptual alignment of IMSV with established improvement theory.

From a theoretical standpoint, these findings also highlight the role of visual and integrated process representations in supporting Lean implementation in service environments. By consolidating process information, actor responsibilities, and value classification within a single framework, IMSV may facilitate shared understanding and coordination among stakeholders, which are critical enablers of continuous improvement. Nevertheless, this effect is likely influenced by contextual factors such as team engagement, organizational culture, and the level of familiarity with Lean practices, and therefore should be interpreted with caution.

The claim of replicability across service sectors rests, however, on the structural and methodological design of IMSV rather than on sector-specific empirical evidence. IMSV intentionally relies on universally applicable constructs – process identification, role-based activity mapping, waste reduction, and workload balancing – rooted in core Lean and Six Sigma principles [55,65]. Its emphasis on simplicity, visual management, and collaborative mapping was explicitly designed to address common constraints across tertiary-sector organizations, such as limited data availability and low Lean maturity. This structured procedural description enables other researchers and practitioners to replicate the model in comparable service environments, even when quantitative performance datasets are limited or unavailable.

From a broader perspective, these outcomes are consistent with prior Lean Six Sigma case studies in service industries, which emphasize process standardisation, role clarity, and visual management as central mechanisms for sustainable performance improvement. However, IMSV extends existing approaches by offering a structurally integrated, low-complexity model that is particularly suited to organizations with limited Lean maturity and constrained data availability. Rather than relying on formal statistical performance measurement, this study adopts a process-centred evaluation strategy grounded in direct observation, stakeholder validation, and structured activity analysis – an approach that is both methodologically appropriate and practically meaningful in the studied context. This synthesis reinforces IMSV's contribution as a framework for complex service systems, particularly within automotive after-sales and insurance-related operations.

6. Conclusions

The integration of Lean and Six Sigma methodologies is increasingly critical for organizational efficiency. However, existing tools often lack the simplicity and accessibility needed for widespread adoption, particularly in service-sector organizations without specialized expertise. This study addresses that gap by proposing the Integrated SIPOC-VSM Model (IMSV), which combines VSM adapted from Lean with the SIPOC tool from Six Sigma.

Traditional VSM, while effective in manufacturing, proves difficult to adapt to service environments. To overcome this limitation, IMSV incorporates a service-oriented VSM variant (similar to Makigami) embedded within the "Process" stage of SIPOC. This integration creates a unified framework that consolidates process information while maintaining visual clarity and collaborative accessibility. The model was developed and refined through a case study at a collision repair workshop.

IMSV evaluation demonstrates substantial operational improvements. The current-state versus future-state comparison revealed a 29.6% reduction in overall process activities (approximately 30%), while the arithmetic mean reduction across the seven key processes was 26.9% (approximately 27%). Planning showed the largest reduction among the key processes, at 45.5%. Beyond activity reduction, IMSV improved workload distribution across team members. The collision manager's assigned activities decreased from 34 to 19, corresponding to a 44.1% reduction (approximately 45%), while the average reduction across the six responsible actors was 22.1% (approximately 22%).

Three distinctive features define IMSV's contribution: (1) Simplicity and accessibility—the model requires no specialized Lean Six Sigma training, enabling application by cross-functional teams; (2) Collaborative transparency—all stakeholders can visualise and contribute to process redesign at any implementation stage; (3) Responsibility rebalancing—the model systematically redistributes workload among actors, addressing a gap unaddressed by existing SIPOC-hybrid frameworks.

As for limitation, this study presents IMSV as an analytically generalizable model grounded in theoretical design principles rather than empirically validated across multiple contexts. Cross-sector replicability remains a theoretically supported proposition requiring further empirical evidence. Key limitations include: absence of external expert review, lack of customer satisfaction measurement, single-case validation, and the absence of benchmarking against alternative process improvement methodologies such as standalone VSM, SIPOC, or DMAIC.

Additionally, the study does not include statistical significance testing or confidence interval analysis. As a qualitative, single-case study, the findings are not intended to support statistical generalization but rather analytical generalization. Future research could incorporate quantitative performance data and statistical validation to further assess the model's impact.

As for future studies, we propose three research directions: (1) Multi-case replication across diverse service sectors (healthcare, financial services, telecommunications, tourism); (2) Longitudinal implementation using IMSV iteratively as a continuous improvement tool, treating each future state as the next current state; (3) External validation through independent expert evaluation and customer outcome assessment. These steps will substantiate IMSV's broader applicability and consolidate its position as a flexible, resilient tool for service process improvement.

CRediT authorship contribution statement

Daniel Botas: Writing – original draft, Investigation, Conceptualization. **Angela Neves:** Writing – original draft, Investigation, Conceptualization. **Florinda Matos:** Writing – review & editing, Supervision, Investigation, Conceptualization. **Radu Godina:** Writing – review & editing, Supervision, Investigation, Conceptualization.

Ethics approval and consent to participate

The study was conducted as an organizational case study with the authorization and cooperation of the company. Participants involved in the observations, interviews, and process discussions were informed about the purpose of the study and participated voluntarily. No personally identifiable information concerning employees or customers was collected or reported. Internal company records were accessed solely for the purposes of process analysis and were treated confidentially. As the study focused on organizational processes and operational improvement, without clinical intervention, experimentation, or collection of sensitive personal data, formal ethics committee approval was not required.

Availability of data

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Declaration of generative AI and AI-assisted technologies

In the preparation of this article, the authors used a generative AI-based tool ChatGPT-4 to assist with language refinement and grammar checks. The authors reviewed and verified all AI-generated content to ensure its accuracy and integrity and take full responsibility for the final manuscript.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Radu Godina reports financial support was provided by Foundation for Science and Technology. Angela Neves reports financial support was provided by Foundation for Science and Technology. The corresponding author (Florinda Matos) declares her interest as an Associate Editor for Heliyon. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2026.e45590.

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