A Model for Institutional Facility Layout Management in a Growing Manufacturing Company

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Abstract: The accelerated expansion of the manufacturing sector in Mexico, driven by nearshoring dynamics and the growth of the aerospace industry in Sonora, has increased the need for strategic management of productive floor space. This study proposes an institutional model for layout management in a growing manufacturing company to standardize processes, strengthen internal coordination, and improve decision-making related to physical infrastructure. The methodology was structured into four stages. First, an initial diagnostic—based on document analysis, surveys, and on-site assessments—identified gaps in information control, role definition, space utilization, and interdepartmental communication. Second, an institutional framework was established to formalize governance principles, guidelines, and responsibilities. Third, a management model was developed, integrating operational workflows, documentation repositories, and a system of layout performance indicators (CG, PAU, and FLF). Finally, the model was implemented in a pilot area, validating its applicability and enhancing standardization and traceability of layout changes. The results confirm that the model provides a robust and replicable tool for strategic layout management in manufacturing environments undergoing growth or reconfiguration.

Keywords: Facility layout, Institutional model, Layout management, Layout performance indicators, Strategic facilities planning.

1. Introduction

Mexico's manufacturing sector has undergone accelerated growth in recent years, driven by global nearshoring trends and the rapid expansion of the aerospace industry in Sonora [1], [4]. These dynamics have increased pressure on companies to manage their production floor space strategically, ensuring operational continuity, cost efficiency and adaptability. However, in organizations experiencing rapid expansion, layout-related decisions frequently remain informal, decentralized and weakly documented, resulting in inconsistent space allocation, limited capacity forecasting and fragmented communication among departments.

Although extensive literature exists on facility layout problems, optimization methods and strategic facility planning [5], [8], most studies emphasize technical design or algorithmic approaches while overlooking the institutional governance mechanisms required to manage layout decisions in growing manufacturing environments. The absence of standardized procedures, clearly defined roles, version-controlled documentation and integrated performance indicators has been identified as a critical gap in both scientific literature and industrial practice. This gap is particularly relevant for companies embedded in the aerospace supply chain in northern Mexico, where fast scaling demands formal governance structures to maintain the integrity and traceability of layout modifications [2], [3], [9].

The company analyzed in this study exemplifies this challenge. Prior to the development of this work, layout files lacked proper version control, modifications were executed independently by different departments and no systematic methodology existed for evaluating space utilization or functional proximity. Similar issues have been documented in studies addressing layout effectiveness, information governance and the need for structured institutional approaches [6], [7], [8], [10]. These conditions increased the risk of space saturation, hindered long-term planning and threatened operational efficiency as growth continued.

This research aims to answer the following question:

What institutional model can effectively support strategic layout management in a growing manufacturing company?

The objective of this study is to develop and validate an institutional model that formalizes layout governance through clearly defined roles, standardized workflows, documentation protocols and quantitative indicators such as Productive Area Utilization (PAU), Closeness Gap (CG) and Flexibility Level of Facilities (FLF) [6], [8], [10].

The main contribution of this study lies in integrating institutional governance principles with facility layout measurement methodologies into a unified, replicable and scalable model applicable to manufacturing organizations undergoing expansion or reconfiguration of their physical infrastructure.

2. Literature Review

The theoretical foundations of this study are built on three major domains: (1) institutional and strategic management frameworks, (2) facility layout methodologies and performance indicators, and (3) organizational implications for layout governance in manufacturing growth contexts. Together, these bodies of literature support the development of an institutional model for layout management.

2.1Facility layout and strategic space management

Facility layout is fundamental to operational effectiveness, influencing material flow, productivity and the efficient use of physical resources. Classical studies emphasize that layout decisions are strategic and shape long-term operational performance, particularly in manufacturing environments facing growth or reconfiguration pressures. Drira et al. [5] provides a comprehensive overview of facility layout problems, highlighting the need to integrate spatial efficiency with functional relationships.

In rapidly expanding organizations, layout management requires not only technical arrangements of equipment and workstations, but also alignment with broader strategic objectives. Montoya Restrepo and Montoya Restrepo [11] describe organizational strategy as a coordinated set of decisions that guide structural configurations—an idea that reinforces the relevance of intentional, governed layout planning.

2.2Systematic Layout Planning (SLP)

Systematic Layout Planning (SLP), developed by Muther [12], remains one of the most influential methodologies for facility layout design. SLP structures spatial planning into sequential phases that analyze process flows, activity relationships and space requirements to generate alternatives for facility arrangements.

Within manufacturing environments experiencing continuous change, SLP provides a formal, repeatable and transparent framework for layout development. Its emphasis on relationship charts and activity interdependence aligns closely with the needs of organizations seeking greater standardization and traceability in their layout decisions.

2.3Layout performance indicators: PAU, Closeness Gap and FLF

Quantitative evaluation of layout effectiveness has become increasingly important in both research and practice. Raman and Nagalingam [6], [7], [13] propose metrics such as Productive Area Utilization (PAU) and the Closeness Gap (CG) to measure how effectively space is used and how closely the layout aligns with desired functional relationships. These indicators allow organizations to move beyond subjective assessments toward data-driven decision-making.

More recent contributions extend layout evaluation frameworks toward flexibility. Kovács [8] introduces approaches to assess efficiency and adaptability, while Trubetskaya et al. [10] integrate Design for Lean Six Sigma principles into strategic space management. These perspectives underscore the need for multi-dimensional measurement systems capable of supporting long-term planning in dynamic manufacturing environments.

2.4Institutional and governance perspectives on layout management.

Although technical methodologies for layout design are well established, fewer studies address the institutional structures required to manage layout decisions within growing organizations. Organizational governance literature, including Mintzberg's schools of strategy as discussed by Montoya Restrepo and Montoya Restrepo [11], highlights the importance of formal roles, decision pathways and information control in ensuring consistent execution of long-term strategies.

Applied to facility layout, this perspective reveals a gap in the literature: most studies focus on optimization techniques but rarely incorporate governance mechanisms such as standardized workflows, version control of layout files or cross-functional approval processes. This gap is especially critical in manufacturing companies undergoing expansion, where weak governance can undermine operational efficiency even when technical layout solutions are sound.

2.5Identified gaps

The review reveals three gaps that justify the development of an institutional model for layout management:

1. Limited integration of governance with layout methodologies: Existing studies emphasize technical optimization but overlook decision structures and documentation practices.
2. Insufficient frameworks for layout control in growing organizations: Research seldom addresses the complexities of managing layout changes during rapid expansion.
3. Lack of standardized indicators embedded within institutional processes: Although PAU, CG and flexibility metrics exist, they are rarely integrated into a formal governance model.

This study addresses these gaps by proposing an institutional model that combines governance elements, operational workflows and quantitative indicators to support strategic, transparent and traceable layout management in manufacturing organizations.

3. Methodology

The methodological design of this study followed a structured, multi-stage approach aimed at diagnosing the existing layout management practices, establishing an institutional framework, developing a governance-based model and validating its applicability within a pilot area. The approach integrates elements of Systematic Layout Planning (SLP) [12], facility layout effectiveness measurement [6], [7], [13], strategic space management principles [10], [15], and governance-oriented perspectives drawn from institutional and organizational strategy literature [11], [16].

3.1 Research design

The study adopted an applied, mixed-method research design aligned with the needs of organizations undergoing physical expansion. The process combined qualitative techniques—such as document analysis, interviews and workflow mapping—with quantitative evaluation using layout performance indicators, including Productive Area Utilization (PAU), Closeness Gap (CG) and flexibility metrics derived from Lean Six Sigma–based space management frameworks [6], [7], [10], [13], [16].

3.2 Stage 1: Initial diagnostic

The first stage consisted of a comprehensive diagnostic assessing the company's layout management practices. This included:

- Analysis of historical layout files, engineering documents and approval records.
- A physical walkthrough of the facility to compare documented layouts with the actual floor.
- Interviews and questionnaires with key stakeholders from Engineering, Operations, Facilities and Production Planning.

This stage revealed gaps in version control, undocumented changes, dispersed responsibilities and limited use of layout indicators—conditions consistent with the governance and coordination challenges reported in the literature [5], [11], [14].

3.3 Stage 2: Institutional framework definition

Based on the diagnostic findings, a preliminary institutional framework was developed to formalize layout governance. The framework defined:

- Roles and responsibilities linked to layout management.
- Decision-making pathways for approving changes.
- Documentation and version-control standards.
- Core principles derived from strategic space planning guidelines established by IFMA [15].
- Alignment with organizational strategy as conceptualized by Montoya Restrepo and Montoya Restrepo [11].

This stage laid the foundation for designing a model that integrates governance, communication and operational control.

3.4 Stage 3: Model development

In the third stage, the institutional model for layout management was constructed. The model consisted of:

- Standardized workflows defining the steps to propose, evaluate, approve and implement layout changes.
- A centralized digital repository for version-controlled layout files.
- Checklists and validation forms structured in accordance with SLP logic [12], but adapted to the company's operational context.
- A performance measurement system integrating PAU and CG indicators [6], [7], [8], [10], [13], [16].

This structure enabled the transition from informal, decentralized decisions to a systematic, traceable and metric-based layout governance process.

3.5 Stage 4: Pilot implementation and validation

The model was implemented in a critical production area selected for its high frequency of layout changes and operational interdependencies. The validation involved:

- Applying the standardized workflows to real modification requests.
- Measuring PAU and CG before and after selected changes.
- Evaluating compliance with documentation and approval protocols.
- Collecting feedback from stakeholders to refine the model.

The results demonstrate improvements in standardization, traceability and cross-functional coordination—addressing long-standing gaps identified in both the diagnostic phase and the literature on layout governance and space management [5], [10], [11], [16].

4. Results and Discussion

This section presents the main findings derived from the application of the methodological procedure for designing an institutional model for layout management in a growing aerospace manufacturing plant. The results are organized into four parts: (1) initial diagnostic of layout management, (2) definition of the institutional framework, (3) design of the layout management model with integrated flows and indicators, and (4) pilot implementation in a selected production area, including the evaluation of efficiency metrics.

4.1 Initial diagnostic of layout management

The initial diagnostic provided an integrated view of the current state of layout management in the plant. It revealed gaps in documentary control, unclear assignment of responsibilities, limited knowledge among personnel, discrepancies between the official layout and the physical distribution, and serious limitations in the indicator used to support decision-making.

4.1.1 Documentary control and information storage

The analysis began with a review of the public digital folder used to concentrate layout-related files (Fig. 1). This folder contained the official plant layout in CAD format, a layout instruction sheet, a basic AutoCAD guide and a text file used as a change log. None of these documents were under formal control in the company's electronic document management system (GED), and all were openly editable.

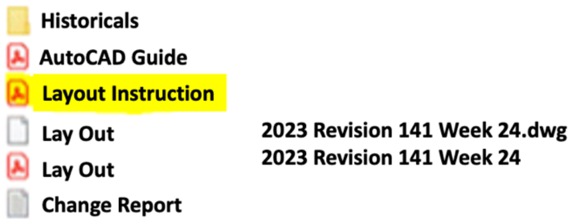


Figure 1: Public digital folder containing layout-related files

This situation created three critical risks:
1. layout files could be modified or deleted without traceability.
2. there was no guarantee that users would consult the latest approved version, and
3. the change log was incomplete and inconsistent.

A detailed review of the change log confirmed missing entries between successive revisions and lack of standard information (such as dates, person responsible or precise descriptions of the modification) shown in Table 1. These findings showed that, although the company had an "official" layout file, it lacked the institutional mechanisms required to preserve its integrity and historical record.

The arrangement of the dining hall tables was modified due to social distancing.
Revision 90 – Week 3:
The cost driver layer was added for the m² report.
Revision 107 – Week 45:
The molding tool clip was updated.
Revision 108 – Week 46:
The layout of the upper-floor plating area was updated.
Revision 110 – Week 46:
The layout of Warehouse Bay 1 and Bay 2 was updated.
Revision 114 – Week 10:
The Cost Driver layer was updated.
Revision 115 – Week 10:
The Cost Driver layer was updated.

Table 1: Example of the "Layout Change Report" file.

The search in the GED system reinforced this conclusion. Only one controlled document related to layout was found: the procedure for calculating the Cost Driver/m² indicator. The document titled "Layout Instruction" in GED was not actually a layout procedure, but a guideline for scanning and archiving production orders (Fig 2). Thus, there was a clear misalignment between institutional records and the documents effectively used for layout management.

Figure 2: Search results in the GED system.

A summary table of the identified documents showed that:

- the layout instruction sheet and the official layout were stored in the public folder and lacked control;
- the change log contained incomplete information;
- the Cost Driver/m² procedure was the only controlled document, but it only addressed indicator calculation and not layout governance;
- training checklists did not define layout-related responsibilities.

4.1.2 Responsibilities and perceived knowledge

To examine whether layout responsibilities were explicitly assigned and understood, the training checklists for production engineers and a survey were analyzed. The checklists formally defined several functions but did not mention activities related to updating, validating or protecting the official layout.

In contrast, survey results suggested that most engineers believed they knew the location of the official layout and were familiar with their general responsibilities. However, only a fraction reported knowing a formal procedure for updating the layout or accessing it. Some respondents even indicated they were unaware of the existence of such a procedure.

This mismatch between what is documented and what personnel perceive as their responsibility revealed an early governance gap: layout management existed in practice as a shared but diffuse task, unsupported by clear institutional definitions.

4.1.3 Physical audit of the layout

To contrast declared knowledge with actual practice, a physical audit (gemba) was carried out in a pilot production area. A verification template was designed to compare the physical distribution of stations, equipment and free areas with the official layout (Fig 3).

Objective:
Inspect and verify the audit points throughout the area, ensuring compliance with the Layout procedure.

Place a ✓ if the inspected point meets the established criteria, otherwise place a ✕ if it does not meet the criteria or good practices, in case of not occupying a space place an N/A.

		Conform / Not Conform	Comment
1	**Print the Layout of the area to be audited from the official document.**		
1.1	Verify that the location of the stations, machines and racks of the productive zones coincide exactly with the Layout.	✕	In all lines there are tables, racks and/or stations missing and/or arranged differently.
1.2	Machines and stations correctly identified in the Layout.	✕	Stations without being identified both in the official layout as on floor.
1.3	The material/machinery stored in the spaces 'B-5' are found placed in the Layout.	✕	There is a table that is not in the layout and there is a machine that is not in place.
1.4	The furniture within the offices inside the production area matches the Layout.	N/A	N/A
2	**Select 1 length of the or the free space(s) and 2 of the area in general to audit the concordance of the measurements. Use the odometer.**		
2.1	The measurements of the free area exactly match the Layout digital (7.77 m)	✕	In the layout it shows more space than there really is. (2.70 meters)
2.2	The length of the ***long of line 1*** matches the Layout digital. (7.25m)	✕	The length of line 1 is 7.09 meters.
2.5	The length of the ***width of the aisle of line 4*** matches the Layout digital. (1 m)	✕	The width of the aisle measures 90 cm. There is a difference of 10 cm.
2.6	The length of the ***long of the automated line*** matches the Layout digital. (4.07 m)	✓	Matches.
2.7	The length of the ***long of the aisle of line 3*** matches the Layout digital. (1.11 m)	✓	Matches.

Figure 3:Results of the production area audited using the verification template.

The audit identified more than 80 discrepancies, including:

- stations located in different positions than in the layout,
- equipment without identification,
- differences of up to 2.70 meters in free area dimensions,
- elements present on the floor but not represented in the layout, and vice versa.

These inconsistencies were marked directly on printed copies of the official layout, generating visual evidence of the gap between the document and reality. When contrasted with the survey, the results showed a clear disconnection: although personnel stated that they knew the procedures and their roles, the physical evidence proved that the layout was neither updated nor used as a reliable reference.

4.1.4 Analysis and deconstruction of the Cost Driver/m² indicator

A critical part of the diagnostic was the analysis of the Cost Driver/m² indicator, which was the only layout-related metric formally registered in the GED and used in management dashboards.

First, the components of the indicator shown in Equation 1 were reviewed:

- Square meters in use,
- Allocated cost drivers,
- Productive capacity,
- Number of pieces produced.

$$(1) Efficiency = \frac{\dfrac{Cost\ drivers}{Square\ meters\ in\ use}}{\dfrac{Productive\ capacity * Cost\ drivers}{Pieces\ produced} \Big/ Square\ meters\ in\ use}$$

The company's intention was to represent layout efficiency by relating cost, area and output. However, when the actual equation (1) used in practice was examined and algebraically simplified, it became evident that the area term (m²) was cancelled out, leaving only a ratio between production and installed capacity. In other words, the indicator had stopped measuring spatial efficiency and had become, in fact, a productivity indicator.

When applied to different areas of the plant, the indicator produced "efficiency" values greater than 100% in some departments. At the same time, gemba walks in those same areas revealed evident physical inefficiencies: long walking distances, poorly arranged equipment and unnecessary internal movements.

To validate these observations, a workshop was held with managers and key stakeholders. Together they defined four criteria that a sound layout indicator should meet:

1. Clearly reflect whether an area is in optimal condition.
2. Be easy to understand.
3. Be known and used by those responsible for managing it.
4. Support strategic decision-making.

The existing Cost Driver/m² indicator was then evaluated against these criteria using a simple matrix. The result was stark: the metric only partially met the first criterion and failed on the remaining three, achieving an overall compliance level of 12.5%(Table 2).

Criterion	Value
Complies	1
Partially	0.5
Does not comply	0

Cost Driver m²	¿Do we have a metric?	Current
It indicates whether we are doing well or badly.	Partially	0.5
it's understandable	No	0
The involved parties know the metric	No	0
Helps decision-making	No	0

Table2: Assessment of the current efficiency indicator based on validity criteria.

In practical terms, this means that managers were making decisions with an indicator that neither measured what it claimed to measure nor was comprehended by the people expected to manage it. This "deconstruction" of the indicator was one of the most powerful findings of the diagnostic: it demonstrated that the problem was not only technical (files, drawings, dimensions), but also institutional and conceptual.

4.2 Institutional Framework for Layout Management

The second stage focused on defining an institutional framework that would give structure, coherence and strategic alignment to layout management.

4.2.1 Strategic recognition of layout management

At the corporate level, layout management was formally recognized as a high-impact strategic project in the company's 2024 Hoshin Kanri. One of the lines explicitly stated "Layout Project at OBR (Assure m² + 2027)", confirming that the organization viewed space management not as a local operational issue but as a key enabler for growth and capacity assurance toward 2027 (Fig 4).

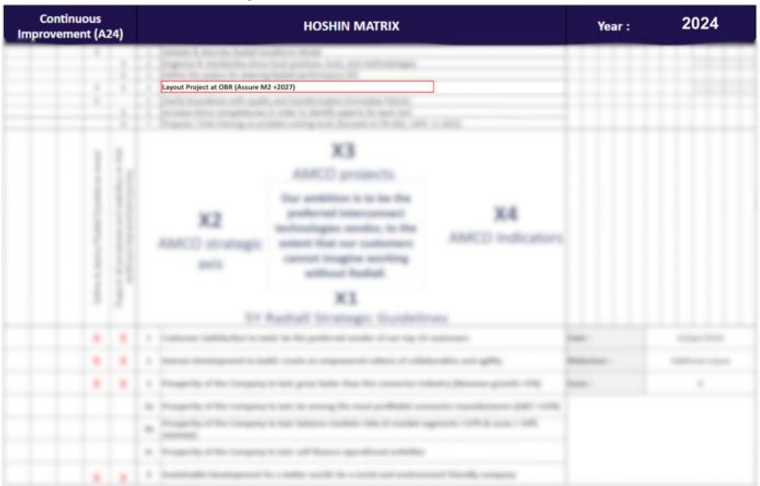


Figure 4:Company's 2024 Hoshin Kanri.

This recognition provided an institutional mandate: any proposed model had to be aligned with long-term strategic objectives and with corporate continuous improvement initiatives.

4.2.2 Guiding principles and link to diagnostic gaps

Based on the diagnostic, four guiding principles were defined and explicitly linked to the gaps identified in Table 3.

Diagnostic Gap Identified	Defined Guiding Principle	Brief Description of the Principle
Lack of document control	Document control	All layout changes must be recorded in the GED system with full traceability.
Dispersed and non-standardized procedures	Standardization	Use of unified formats and workflows across the entire plant.
Limited and poorly understood Cost Driver/m² indicator	Systematic measurement	Periodic evaluation of layout performance using indicators (PAU and CG).
Misalignment between the layout and corporate strategy	Strategic alignment	Strategic guideline "Layout Project at OBR (Assure M2 + 2027)".

Table 3: Four defined guiding principles

4.2.3 Multilevel dynamics for strategic layout management

To operate these principles, layout management was structured into three decision levels:

- Operational level: controls and validates everyday changes in the layout, ensuring that the official layout in GED always reflects the real configuration on the shop floor.
- Tactical level: performs periodic diagnoses of space use (including Cost Driver/m² and new indicators) and triggers local improvement projects in specific areas.
- Strategic level: evaluates capacity projections and defines high-impact projects such as expansions or major reconfigurations over a three-year horizon.

This tri-level structure is consistent with contemporary facility-planning literature, which emphasizes the need to link local layout decisions with medium- and long-term strategic planning.

4.2.4 Stakeholder mapping

A stakeholder map was developed to identify actors by power and interest. Plant and operations managers, area managers and the continuous improvement manager were located in the high-power, high-interest quadrant, as they are the main decision-makers in space-related projects. In contrast, building coordination, EHS, IT and AMCO technical staff were positioned as high-interest but lower power stakeholders, essential for technical feasibility and compliance but not final decision-makers. Engineers in manufacturing and production were mapped as having medium relative power with primarily operational roles (Fig 5).

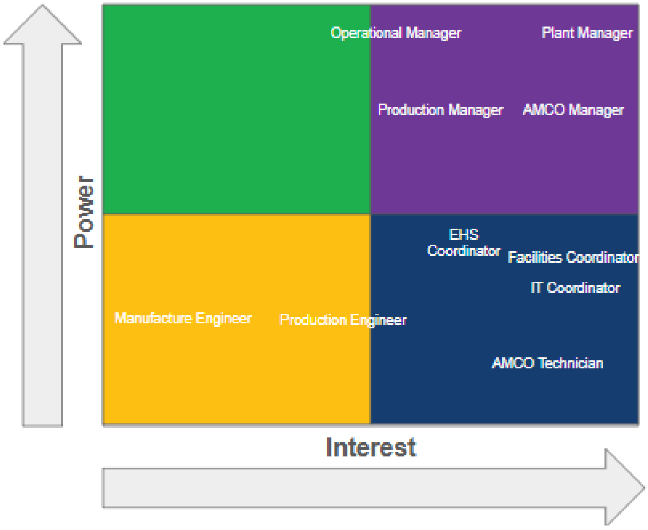


Figure 5: Stakeholder map for layout management.

This structure aligns with other studies on strategic facility and space planning, which also highlight the central role of operations and plant management and the supporting but crucial influence of technical and safety profiles.

4.3 Layout Management Model: Flows, Documentation and Indicators

Building on the institutional framework, the third stage consolidated the layout management model itself, integrating decision dynamics, formal procedures and performance indicators.

4.3.1 Integration into the document management system

The first concrete outcome was the integration of layout-related documents into the GED system as controlled records. The instruction sheet, the formal procedure and the official layout were all registered as institutional documents, ensuring permanent availability, controlled updates and automatic notification of changes to relevant stakeholders.

This step closed one of the most critical gaps identified in the diagnostic: the absence of formal document control for layout information.

4.3.2 Operational, tactical and strategic dynamics with RACI matrices

For each of the three decision levels, a management dynamic was defined and formalized with a RACI matrix and a process flow:

- Operational dynamic – Layout validation flow:
  A detailed RACI matrix assigned responsibility for each activity (e.g., AMCO technician and production engineer as responsible, management and EHS as approvers or informed). The flow diagram documented successive validations from change request to GED update and physical implementation.
- Tactical dynamic – Cost Driver/m² review:
  A second RACI matrix specified the roles for periodic audits of the layout and generation of Cost Driver/m² reports. The flow included gemba visits, analysis of space use and communication of findings. Although the Cost Driver/m² formula was conceptually limited, the dynamic ensured that space audits and discussions around area occupancy became part of a routine, structured process.
- Strategic dynamic – three-year layout projection:
  The third RACI matrix and process flow focused on projecting the layout over a three-year horizon, assigning technicians and engineers to prepare and validate annual layouts, and plant and operations managers to approve them. Activities ranged from identifying future needs and constraints to consolidating projected layouts and presenting conclusions to management.

These three dynamics were consolidated into a single institutional instruction and an associated procedure, differentiating between the "how" (detailed steps and roles) and the "normative framework" (policies, scope and rules governing layout changes). All of this was then embedded in the GED system.

4.3.3 Identification of key dimensions and indicators

Joint sessions with production engineers identified three critical dimensions affecting layout performance:

1. Flexibility – limitations caused by fixed machines, rigid structures, non-modular furniture, saturated spaces and infrastructure constraints (e.g., power or network connections).
2. Proximity – deficiencies in station arrangement, indirect routes, physical restrictions, isolated workstations and poorly positioned equipment.
3. Productive Area Utilization (PAU) – practices that limit space efficiency, such as oversized safety areas, in-process warehouses inside production, unbalanced or unused stations and obsolete or inactive machines.

These dimensions were visualized in a conceptual map and then connected to established formulas in the literature for PAU, Closeness Gap (CG) and an integrated layout efficiency index (Fig 6). The study adopted these formulas as methodological references without modification, positioning them as a robust basis for quantitative evaluation in the pilot phase.

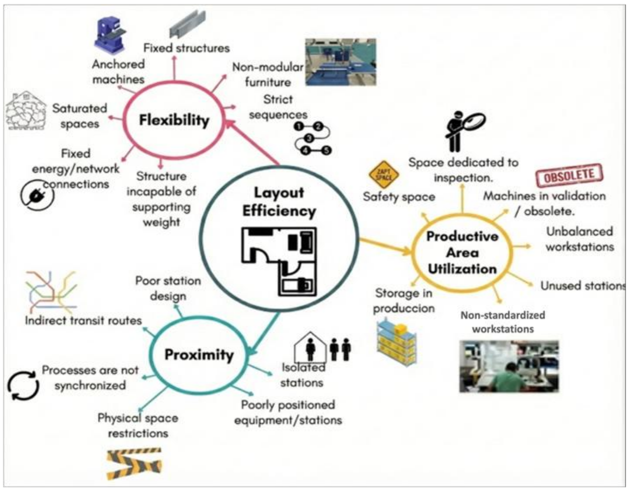


Figure 6: Mind map of factors affecting layout efficiency.

Finally, an overview diagram of the institutional model was created, integrating the institutional framework, the three management dynamics and the indicator system into a single coherent architecture (Fig 7).

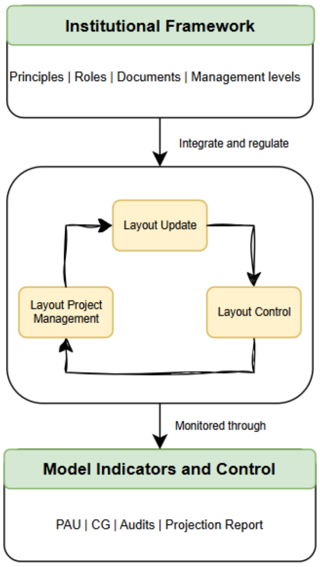


Figure 7: Institutional model for layout management.

4.4 Pilot Implementation in a Production Area

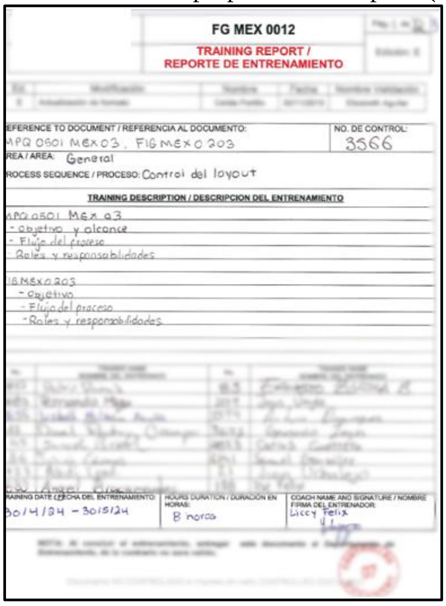
To validate the applicability of the proposed model, a pilot implementation was conducted in Nave 1, which hosts the Multipin business unit (Sub-assembly, Final Assembly and Molding). This nave has the largest productive surface in the plant, making it a critical area for future growth and an ideal environment to test the model.

4.4.1 Training and preparation of personnel

A structured training session was developed to present the model to the personnel involved. The session explained:

- the three dynamics (operational, tactical and strategic),
- their objectives,
- main activities,
- and roles and responsibilities.

During the workshop, participants were shown how to access the official documents in GED (procedure, instruction sheet and official layout). Attendance and completion were documented through a formal training record, which became controlled evidence that the area had been prepared for the pilot (Fig 8).


FG MEX 0012
TRAINING REPORT / REPORTE DE ENTRENAMIENTO

EFERENCE TO DOCUMENT / REFERENCIA AL DOCUMENTO: MPQ 0501 MEX03, FIG MEX0203
NO. DE CONTROL: 3566
REA / AREA: General
ROCESS SEQUENCE / PROCESO: Control del layout

TRAINING DESCRIPTION / DESCRIPCION DEL ENTRENAMIENTO
MPQ 0501 MEX 03
- objetivo y alcance
- Flujo del proceso
- Roles y responsabilidades

IG MEX0203
- Objetivo
- Flujo del proceso
- Roles y responsabilidades

RAINING DATE (FECHA DEL ENTRENAMIENTO): 30/4/24 – 30/5/24
HOURS DURATION / DURACION EN HORAS: 8 horas
COACH NAME AND SIGNATURE / NOMBRE FIRMA DEL ENTRENADOR: Liccy Felix

Figure 8: Official personnel training record.

This step aligned with change-management recommendations in the literature, emphasizing clear communication and standardized training to reduce resistance and ensure consistent understanding.

4.4.2 Application of the validation flow

The first tangible result of the pilot was the application of the layout validation flow at the operational level. A chain of emails documented each step of the process: initial request, technical review, validations by production, area management, EHS, IT and maintenance, and final authorization.

This evidence confirmed that the process no longer depended on a single actor, but instead integrated multiple perspectives and ensured formal approval. Once the change was validated, the updated layout was registered under official control in GED, closing the loop between physical execution and documentary traceability.

4.4.3 Strategic projection and linkage to expansion projects

At the strategic level, the three-year projection dynamic was applied to Building 1. A projection report consolidated estimates of space occupation and availability for the period 2025–2027 as shown in Fig 9. The quantitative summary showed a progressive reduction in available space, from 231 m² in 2024 to only 82 m² in 2027—equivalent to 1.52% of total area—indicating a critical saturation risk.

Figure 9: Report on projections regarding space occupancy and availability for the period 2025-2027

Based on this analysis, a strategic expansion project, "Layout OBR 2028", was formally registered in the corporate improvement portfolio, with assigned resources, responsibilities and follow-up. Thus, the model translated a spatial risk identified through the projection into a concrete strategic initiative.

The projections also highlighted specific operational needs, such as the saturation of Line 3 in Sub-assembly by 2026, which required internal redistribution to absorb expected demand.

4.4.4 Application of CG and PAU in the pilot line

In response to the saturation risk, the indicators proposed by Raman et al. were applied to Line 3: Closeness Gap (CG), Productive Area Utilization (PAU) and the integrated layout efficiency index.

For the CG calculation, pairs of stations with frequent functional interactions were identified. For each pair, the frequency of interaction (INV) and physical distance (SV) were measured, and a weighted distance (SV × INV) was computed. The sum of these products yielded a Current Closeness Value (CCV) of 760.2 for the existing layout. An "ideal" station arrangement was then simulated by assigning minimal distances to pairs with the highest flows, obtaining a Best Closeness Value (BCV) of 716.4.

The Closeness Gap was calculated as (CCV − BCV)/CCV, resulting in CG = 0.0576, a value close to zero, indicating high proximity efficiency: stations that interact frequently are located relatively close to one another, minimizing unnecessary movement.

For the PAU analysis, areas were classified into production, storage, material handling and inspection/packing. Production accounted for 59% of the space, storage 5%, material handling 31% and inspection/packing 5%. Within each group, the proportion of area dedicated to value-adding activities was estimated, yielding, for example, 45.72% of value-adding space in production and 16.79% in material handling. Consolidating these results, the overall PAU for the line was 0.7220, indicating that approximately 72.2% of the available area is used for value-adding activities.

This level of space utilization is favorable, but also reveals a 27.8% margin for improvement, either by reducing incidental areas or redistributing support zones.

4.4.5 Integrated efficiency index and comparison with literature

Finally, the integrated layout efficiency formula, combining CG, PAU and a flexibility factor, was applied. In this first pilot, flexibility was not evaluated (assigned value and weight of zero), so the result depended mainly on PAU and CG. The calculation returned a layout efficiency index of 0.7881 (78.81%), indicating that the current configuration of Line 3 operates at a level close to 80% efficiency.

These results were compared with ranges reported in the literature. For PAU, values between 0.65 and 0.80 have been documented in real plants with mixed productive and incidental spaces; the value obtained (0.7220) falls within this interval. For CG, efficient layouts typically exhibit values below 0.1; the pilot's CG of 0.0576 complies with this pattern. For the integrated index, published case studies show results between 0.70 and 0.85; the pilot's 0.7881 lies comfortably within this range.

This comparison supports two key conclusions:

1. the indicators and model are methodologically consistent with established references; and
2. the plant's layout performance, at least in the pilot area, is comparable to that of other industrial contexts where these metrics have been applied.

4.5 Overall discussion

The results demonstrate that the proposed institutional model not only addresses the gaps identified in the diagnostic, but also provides a structured mechanism to connect operational, tactical and strategic decisions related to space.

- At the operational level, the model closes the documentation and traceability gap by embedding layout changes into a controlled validation and GED update flow.
- At the tactical level, it transforms the discussion around space from a purely financial or cost-based conversation into a multidimensional analysis using PAU and CG.
- At the strategic level, it links layout management directly with capacity projections and long-term expansion projects, as exemplified by the Layout 2028 initiative.

In doing so, the study fulfills its general objective: to establish an institutional model for layout management in a growing manufacturing company, capable of supporting more reliable and strategic decision-making regarding the use of productive space.

5. Conclusion

The institutional model developed in this study demonstrates that formalizing the governance of layout management can significantly strengthen operational control, mid-term planning and long-term strategic alignment in a growing manufacturing company. By integrating documented principles, standardized workflows, clearly defined roles and validated performance indicators (PAU and CG), the model provides a structured mechanism that reduces ambiguity, improves traceability and supports evidence-based decisions regarding the use of productive space.

A key advantage of the model is its capacity to link daily layout updates with broader tactical and strategic considerations. The pilot application in Sub-Assembly Line 3 confirmed that the selected indicators are practical, reliable and sensitive to changes in space utilization and functional proximity. This validation aligns with previous findings in the literature and reinforces the model's suitability for industrial environments experiencing accelerated growth. Furthermore, the integration of the model with the company's 2028 Layout Strategy shows its potential to serve as a long-term planning tool rather than a mere operational aid.

Nevertheless, the model has limitations. The pilot assessment focused on a single production line, which restricts generalization across all areas of the plant. Additionally, although PAU and CG proved effective, the model would benefit from the incorporation of complementary metrics related to flexibility, ergonomics, economic impact and scenario-based simulation. These elements could enhance the model's predictive capacity, particularly for future reconfiguration projects.

Overall, the institutional model offers a replicable and scalable framework for organizations seeking to manage spatial growth in a controlled and strategic manner. Its application can support cross-functional alignment, improve the reliability of layout decisions and reduce risks associated with uncoordinated expansions. Future work should extend the model to other buildings, evaluate its performance over time and explore digital tools that enable advanced visualization and forecasting of layout changes.

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