# Stage-Gates, Pull Planning, and KPIs for the Reduction of Rework in Commercial Space Management

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## ABSTRACT

The retail shopfitting industry operates under intense pressure from fixed commercial opening dates, high client variability, and fragmented information flows between design, manufacturing, and site installation. These conditions frequently result in documentation errors and on-site rework, which historically accounted for 68 % of operational impact in technical offices. This study designs and validates a hybrid methodology that integrates Concurrent Engineering principles with Lean Construction tools to improve the traceability of client requirements and reduce rework in commercial space management. The approach was structured around four sequential phases Planning, Detailed Engineering and Document Control, Execution and On-Site Assembly, and Closure and Evaluation and operationalized through stage-gates, reverse pull planning, technical checklists, change-control boards, and four key performance indicators: Percentage of Plan Complete (PPC), Technical Deliverables Quality Index (ICET), Person-Days Deviation Index, and Site Incidence Index (IIS).

Validation was conducted through partial implementation in the pilot project of the Oysho Ánima Los Cabos store. Results showed a PPC of 71.43 %, an ICET of 81 %, a person-days deviation of +9.38 %, and a global IIS of 14.38 %. Five of the seven furniture families recorded zero incidences, and 85.7 % of all site non-conformities were traced to inadequate packing of an imported batch rather than local design or manufacturing failures. The methodology made external variability visible, filtered documentation errors before production, protected the fixed opening date, and generated organizational learning without requiring costly enterprise systems.

The findings demonstrate that a low-cost, visually managed hybrid framework is practical and effective for professionalizing technical offices in the retail fixture sector. The study contributes an applied model adapted to high-variability commercial environments and provides a foundation for multi-project replication and longitudinal measurement of warranty reduction.

**Keywords:** stage-gates, pull planning, Lean Construction, Concurrent Engineering, retail shopfitting, rework reduction, key performance indicators, technical traceability

## INTRODUCTION

The retail industry is characterized by constant dynamism, driven by the evolution of consumption habits, the integration of new technologies, and the need to generate memorable experiences in commercial spaces that directly impact brand perception and sales conversion (Hamerski et al., 2019; Project Management Institute, 2021). In this context, the design, fabrication, and installation of furniture and ambiance for stores not only fulfills an aesthetic function but also constitutes a strategic project management tool that demands precision, traceability, and multidisciplinary coordination among conceptual design, detailed engineering, production, and on-site assembly.

Companies specialized in retail equipment, particularly those serving international brands, face significant operational challenges derived from the high variability of client requirements, inflexible commercial opening

deadlines, and the fragmentation of information across the different project phases (Pons & Rubio, 2019). This disconnection generates information leaks, errors in technical documentation (drawings and routing sheets), and frequent rework during installation, which compromises operational efficiency and the quality perceived by the client.

Diagnosis in real operational environments confirms the magnitude of the problem: analyses of representative samples of projects (such as the one covering 71 projects in technical offices of retail equipment companies) reveal that approximately 45% present warranty claims, concentrating 68% of the operational impact in on-site rework (40%) and errors in technical documentation (28%). These deficiencies originate from the absence of standardization, formal incident logs, and preventive control mechanisms, prioritizing operational urgency over systematic prevention (Mayo-Alvarez et al., 2026).

To address this problem, the development of a hybrid methodology is justified that integrates the principles of Concurrent Engineering facilitating early collaboration among design, purchasing, production, and assembly areas with the flexibility and visual control of Lean Construction, incorporating decision gates (stage-gates), checklists, change control boards, reverse-sequence planning (Pull Planning), and the measurement of key performance indicators (Cooper, 2016; Pons & Rubio, 2019).

This approach allows mitigating errors from the origin, ensuring the traceability of client requirements, and adapting to the high-pressure dynamics of the Mexican retail sector without depending on costly ERP systems.

The general objective of the present article is to design and validate an integral methodology for the management and assurance of client requirements in retail equipment projects, with the aim of improving information traceability, reducing errors in technical documentation, and mitigating on-site rework.

Regarding the methodological connection, the study is based on key operational variables the Percentage of Plan Complete (PPC), the Deviation Index in Person-Days, the Quality Index of Technical Deliverables (ICET), and the On-site Incidents Index (IIS) identified and validated through a systematic literature review under the PRISMA protocol of 20 articles published between 2016 and 2026, focused on Lean Construction, collaborative planning, Concurrent Engineering, and project management in high-variability environments such as retail and shopfitting (Page et al., 2021; Mayo-Alvarez et al., 2026). This review allows theoretically grounding the proposed tools and their applicability in a real pilot project.

# LITERATURE REVIEW

## SALSA Methodology Applied

- **Search**: Search in Scopus, Google Scholar, ScienceDirect, Springer, MDPI, IGLC (International Group for Lean Construction), and industrial engineering / project management databases (2016–2026). Keywords: Lean Construction OR Last Planner System OR Pull Planning retail OR shopfitting OR fit-out; Concurrent Engineering OR stage-gate furniture OR retail; rework OR retrabajo documentación técnica; PPC OR Percentage Plan Complete; trazabilidad requerimientos cliente.

- **Appraisal**: Priority given to case studies, systematic reviews, and empirical applications with quantifiable results and direct relevance to variability, on-site rework, documentary errors, and standardization in high-pressure environments (retail / shopfitting).

- **Synthesis**: Grouping by themes (Last Planner / Pull Planning, stage-gates + Concurrent Engineering, checklists and change control, performance KPIs, rework and traceability).

- **Analysis**: Linkage with the root causes of the thesis diagnosis (on-site rework 40%, documentation errors 28%, absence of logs and indicators, empirical planning).

**Table 1. Analysis of the Literature Review**

| # | Author(s) and Year | Title | Search (Source) | Appraisal (Quality/Relevance) | Synthesis (Key Findings) | Analysis (Relation to the Thesis) |
|---|---|---|---|---|---|---|
| 1 | Hamerski et al. (2019) | Combining Lean and Agile Project Management in a Multi-Project Environment: Case Study in a Retail Company | IGLC Proceedings | High (real multi-project retail case) | Lean + Agile integration improves planning reliability in a multi-store environment. | Supports the hybrid approach for managing several brands and simultaneous projects in the Technical Office. |
| 2 | Pons & Rubio (2019) | Lean Construction: Las 10 claves del éxito para su implantación | Book (Consejo General Arquitectura Técnica España) | High (practical framework) | Pull Planning, Obeya, PPC, and constraint management as pillars. | Direct conceptual basis for the proposed reverse planning and visual control. |
| 3 | Cooper (2016) | Agile–Stage-Gate Hybrids | Research-Technology Management | High (consolidated model) | Agile stage-gates reduce uncertainty and allow progressive release. | Justifies the modular decision gates adapted to high-variability retail. |
| 4 | Mayo-Alvarez et al. (2026) | Critical factors in the implementation of Lean Construction: A literature review 2015–2025 | Buildings (MDPI) | High (systematic review) | Critical success factors of LPS; 5S and standardization as starting points in SMEs. | Reinforces the prioritization of low-cost checklists and logs. |
| 5 | Page et al. (2021) | The PRISMA 2020 statement | BMJ | High (methodological guide) | Guidelines for transparent systematic reviews. | Framework of the 20-article review that supports the study variables. |
| 6 | Ballard (2000, cited and updated in 2016+ literature) | The Last Planner System of Lean Construction | Thesis / IGLC | High (foundation) | PPC as the central metric of planning reliability. | Supports the pilot PPC indicator (71.43%). |
| 7 | Love et al. (2018) | The costs of rework: Insights from construction… | Production Planning & Control | High | Rework represents 5–15% of value; frequent origin in documentation and coordination. | Validates the focus on on-site rework (40% of the impact in the diagnosis). |
| 8 | IGLC paper (2026) | Using 4D Models… in Fast-Track Retail Renovation Projects | IGLC | High (retail case) | LPS + 4D improves constraint management in commercial renovations. | Applicable to the logistical complexity of stores (e.g., Los Cabos). |
| 9 | Cabrera Huaycochea (2026) | Implementación del Last Planner System en un proyecto industrial… | Thesis PUCP | Medium-High | LPS improves reliability in projects with multiple trades. | Evidence of applicability in Latin American contexts. |
| 10 | Lean Construction México (2026) | PPC en Last Planner System | Specialized site | Medium-High | PPC target ≥ 80% as an indicator of stable flow. | Allows interpreting the pilot's 71.43% as acceptable under external constraints. |
| 11 | Project Management Institute (2021) | PMBOK Guide (7th ed.) | PMI | High | Requirements management | Supports documentary |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | and change control. | traceability and stage-gates. |
| 12 | Mesher (2010, contextualized 2016+) | Diseño de espacios comerciales | Book | Medium | Branding and visual merchandising as the axis of equipment. | Links checklist criteria (brand fidelity). |
| 13 | Riba & Molina (2006, updated) | Ingeniería Concurrente | Book | High | Early integration of design, production, and assembly. | Foundation of the proposed concurrent collaboration. |
| 14 | Shingo (1986, cited in recent literature) | Zero Quality Control / Poka-Yoke | Classic updated | High | Error-proofing mechanisms. | Justifies checklists and stage-gates as informational Poka-Yoke. |
| 15 | Bicheno (2012, later editions) | The Lean Toolbox for Service and Lean Office | Book | High | Lean Office and elimination of muda in information flows. | Applicable to the Technical Office. |
| 16 | Evans & Lindsay (2015/later eds.) | Administración y control de la calidad | Book | High | PDCA, lessons learned, and logs. | Supports the incident log and improvement cycle. |
| 17 | Koskela (1992, developed in IGLC 2016+) | Application of the new production philosophy… | Reports / IGLC | High | Constraint management and flow. | Basis of Lookahead Planning and constraint management. |
| 18 | Howell (1999, updated) | What is Lean Construction | IGLC | High | Definition and principles of LPS. | Conceptual framework of Pull Planning. |
| 19 | Liker (2004, later eds.) | The Toyota Way | Book | High | Visual management and Obeya. | Supports the use of visual boards and Notion in the pilot. |
| 20 | Lean reviews in SMEs / retail (2024–2026) | Various reviews in Int. J. Lean Six Sigma and similar | Journals | High | 5S, checklists, and standardization are the tools with the greatest initial impact in high-variability environments. | Justifies the low-cost, high-applicability approach without ERP. |

The literature confirms that the central problem of the thesis (lack of standardization and traceability in the Technical Office, on-site rework, and documentary errors) is recurrent in retail equipment and fit-out projects. Studies on the Last Planner System and Pull Planning (articles 1, 2, 6, 8, 9, 10) demonstrate improvements in planning reliability (PPC) and reduction of unreleased constraints, which validates the use of reverse planning starting from the immovable opening date. Proposals of agile stage-gates and Concurrent Engineering (articles 3, 11, 13) support the decision gates and the parallel work among design, production, and assembly. The combination of checklists, change control, and lessons-learned logs appears as the highest cost-benefit approach for environments without costly ERP systems, aligned with the Pareto diagnosis (68% of the impact in rework + documentation).

**Conclusion of the Analysis**: There is a solid and updated empirical basis that justifies the proposed hybrid methodology. The scarcity of specific literature on technical offices for retail furniture in the Mexican context represents an opportunity for applied contribution of the work.

# METHODOLOGY

The project was developed under an applied research approach of mixed type, using a hybrid framework of Concurrent Engineering and Lean Construction. Validation was carried out through partial implementation in the pilot project of the Oysho Ánima Los Cabos store (immovable opening date: May 22, 2026).

**Main Tools Used**:

- Stage-gates (14 operational milestones with exit criteria).
- Technical checklists for routing sheets and drawings.
- Change control board.
- Pull Planning (reverse sequence) and assembly zoning.
- Incident and lessons-learned log (PDCA cycle).
- Key indicators: PPC, Deviation Index in Person-Days, ICET, and IIS.

**Implementation Phases (Aligned to the Project Life Cycle)**

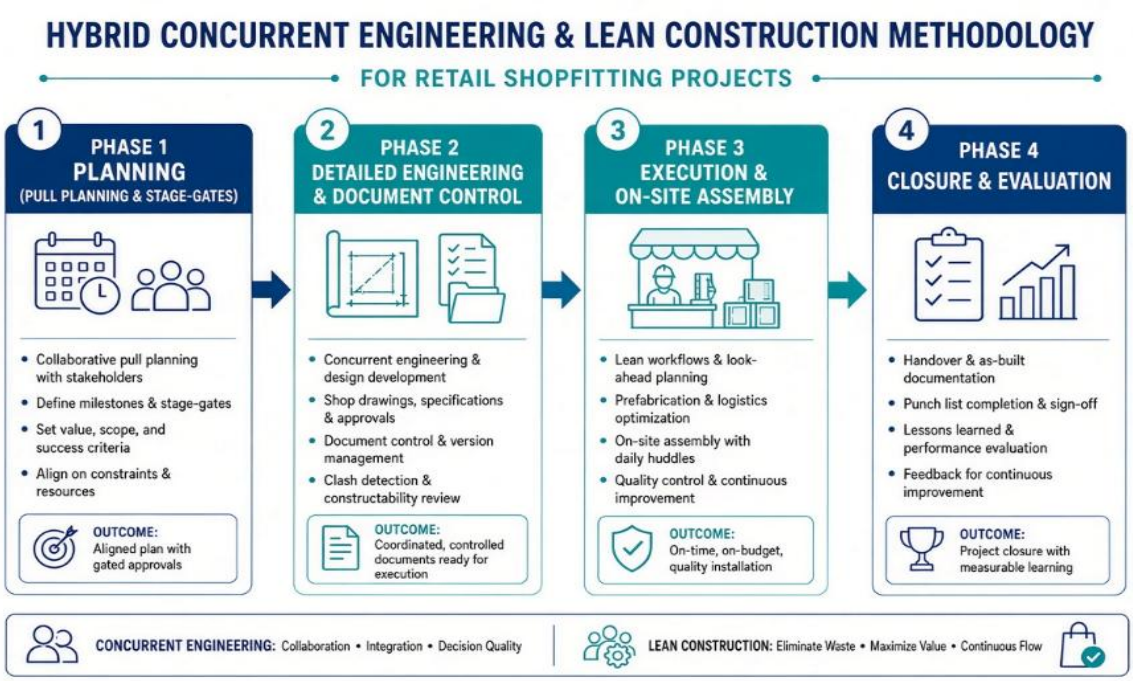



**Figure 1.** Four-phase hybrid methodology integrating Concurrent Engineering and Lean Construction principles for retail fixture and shopfitting projects.

The hybrid methodology of Concurrent Engineering and Lean Construction is structured in four sequential phases aimed at improving the traceability of client requirements and reducing rework in retail equipment projects. In the Planning Phase, Pull Planning (reverse planning starting from the immovable commercial opening date) is applied and stage-gates or decision gates with mandatory exit criteria are established. In the Detailed Engineering and Documentary Control Phase, technical checklists and change control are implemented to ensure the quality of deliverables before releasing them to production, measuring this performance through the Quality Index of Technical Deliverables (ICET). During the Execution and On-Site Assembly Phase, the fabrication and dispatch of furniture are synchronized with the actual progress of the civil works through constraint management and zoning. Finally, in the Closure and Evaluation Phase, on-site incidents are quantified through the On-site Incidents Index (IIS), the Percentage of Plan Complete (PPC) and deviations in Person-Days are recorded, and the lessons learned are documented in the log to feed continuous improvement cycles.

**Phase 1: Planning (Pull Planning and Stage-Gates)**

Objective: Establish the reverse sequence from the opening date and the decision gates. Activities: Definition of the 14 milestones, identification of constraints, collaborative scheduling, and use of the Notion platform for tracking.

Variables: Milestone compliance (PPC).

**Phase 2: Detailed Engineering and Documentary Control**

Objective: Ensure the quality of deliverables before releasing to production. Activities: Mandatory application of checklists, version control, and freezing of technical packages (Rev. 01).

Variables: ICET (% of drawings accepted on the first review).

**Phase 3: Execution and On-Site Assembly**

Objective: Synchronize fabrication and dispatch with the actual progress of civil works.

Activities: Priority management by zones, constraint tracking, and Daily Huddles.

Variables: Deviation Index in Person-Days.

**Phase 4: Closure and Evaluation**

Objective: Measure actual on-site incidents and capture lessons learned.

Activities: Registration of non-conformities by furniture family, calculation of IIS, and update of the log.

Variables and indicators measured in the pilot**:**

- PPC: 71.43% (10 of 14 milestones on time).
- Deviation Person-Days: +9.38%.
- ICET: 81%.
- Global IIS: 14.38% (with 0% failures in 5 of 7 furniture families; 85.7% of the incidents concentrated in one import batch due to stowage deficiencies).

The methodology was designed to be operable without costly specialized software, prioritizing visual and low-cost tools that generate organizational memory and preventive filters (informational Poka-Yoke).

## RESULTS

The results are organized according to the four phases of the proposed methodology. For each phase, the key quantitative findings are presented, followed by an explanatory data table and the recommended figures or tables from the original thesis that support the phase.

**Phase 1: Planning (Pull Planning & Stage-Gates)**

In this phase, traditional push scheduling was replaced by reverse planning (*Pull Planning*) starting from the fixed commercial opening date of 22 May 2026. Fourteen operational milestones were defined and controlled through stage-gates.

**Table 2. Planning Phase Results – Percentage of Plan Complete (PPC)**

| Indicator | Planned | Actual | Result | Status | Main Causes of Non-Compliance (CNC) |
|---|---|---|---|---|---|
| Total operational milestones | 14 | 14 | — | — | — |
| Milestones completed on time | 14 | 10 | 71.43 % | Acceptable | Client document approval delay; Civil works delay |
| Milestones delayed | 0 | 4 | 28.57 % | External factors | Cascade effect on administrative closing |
| **PPC** | 100 % | 71.43 % | — | Controlled | Variability made visible and managed in real time |

A PPC of 71.43 % shows that 10 of the 14 stage-gates were completed on time. The four delayed milestones were mainly caused by external factors (late client approval of drawings and delays by the civil contractor). The methodology made these deviations visible early, allowing contingency actions that protected the fixed commercial opening date. This result demonstrates the capacity of the stage-gate system to absorb external variability without compromising the critical path.

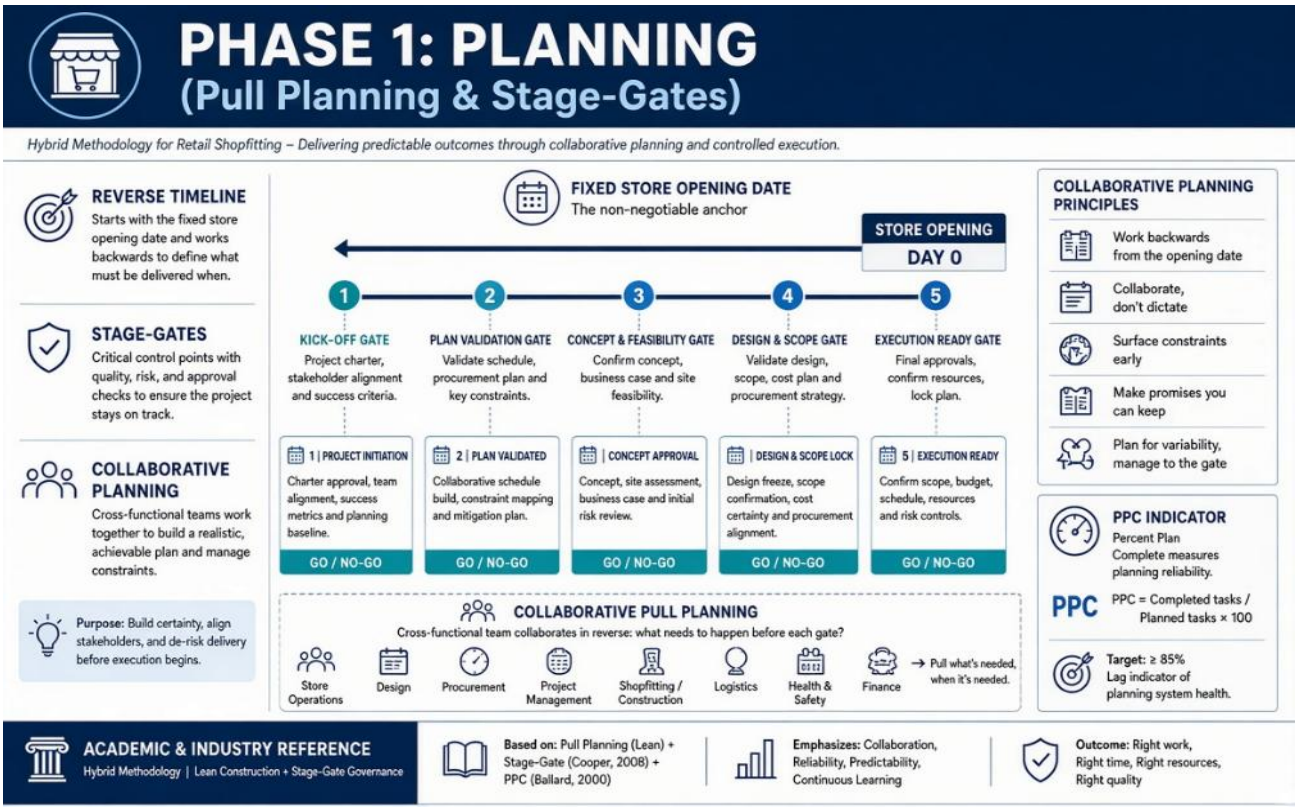



**Figure 2.** Planning (Pull Planning & Stage-Gates)

This phase establishes reverse planning (Pull Planning) from the fixed commercial opening date and controls the project through sequential stage-gates. It ensures that no activity advances without meeting predefined exit criteria, making planning reliability measurable through the Percentage of Plan Complete (PPC).

**Phase 2: Detailed Engineering & Document Control**

Checklists and change-control tables were applied as mandatory filters before releasing any technical package to the manufacturing plant.

**Table 2. Detailed Engineering Phase Results – Technical Deliverables Quality Index (ICET)**

| Designer | Plans Issued | Plans Accepted at First Review | ICET (%) | Main Root Causes Detected | Corrective Action Taken |
|---|---|---|---|---|---|
| Designer 1 | 30 | 25 | 83 % | Outdated title block / template | Template updated before release |
| Designer 2 | 10 | 8 | 80 % | Formula error in route sheet | Corrected before production release |
| Designer 3 | 20 | 16 | 80 % | Incorrect dimensioning (3 decimals) | Note added + correction scheduled |
| **Total** | **60** | **49** | **81 %** | — | 100 % of errors resolved inside Technical Office |

The overall ICET of 81 % indicates that 49 out of 60 technical drawings were accepted on the first review. All detected discrepancies (obsolete templates, calculation errors, and dimensioning inconsistencies) were identified and corrected within the Technical Office before any information reached the manufacturing plant. This preventive filtering avoided the propagation of documentation errors to production and site, which historically accounted for 28 % of the operational impact.

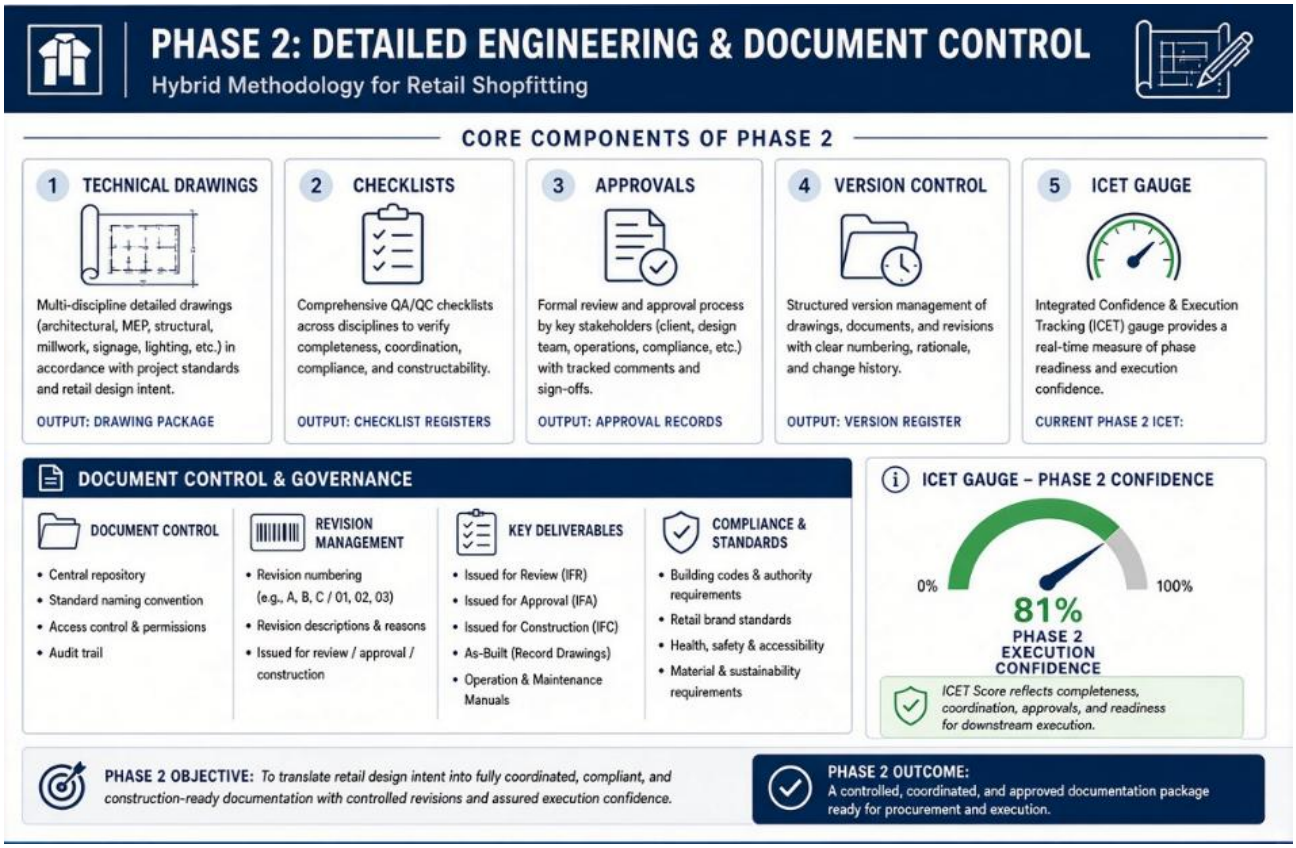



**Figure 3.** Detailed Engineering & Document Control

In this phase, mandatory technical checklists and change-control mechanisms act as preventive filters. They guarantee that drawings and route sheets meet quality standards before being released to manufacturing, with performance measured by the Technical Deliverables Quality Index (ICET).

**Phase 3: Execution & On-Site Assembly**

Fabrication and dispatch were synchronized with the actual progress of civil works through pull scheduling and zoning.

**Table 3. Execution Phase Results – Person-Days Deviation Index**

| Item | Planned | Actual | Difference | % Deviation | Classification |
|---|---|---|---|---|---|
| Number of installers | 6 | 5 | –1 | — | Resource adjustment |
| Installation days | 16 | 21 | +5 | — | Civil works delay |
| **Total Person-Days** | **96** | **105** | **+9** | **+9.38 %** | Underestimated |
| Impact on opening date | — | — | None | — | Opening date protected |

The project recorded a +9.38 % deviation in person-days (105 actual versus 96 planned). The increase was caused by civil contractor delays (floor curing and painting in staff areas) and a coordinated reduction of the installation crew due to concurrent projects. Despite the deviation, the sales floor was delivered with sufficient buffer for visual merchandising, and the commercial opening date was met. The indicator allowed clear isolation of external causes versus internal planning accuracy.

**Phase 4: Closure & Evaluation**

Physical non-conformities were measured and classified by furniture family during site installation.

**Table 4. Closure Phase Results – Site Incidence Index (IIS)**

| Furniture Family | Total Modules | Modules with Incidence | IIS (%) | Main Cause |
|---|---|---|---|---|
| Display Tables | 5 | 0 | 0.0 % | — |
| Cash Modules | 2 | 0 | 0.0 % | — |
| Fitting Rooms & Mirrors | 6 | 0 | 0.0 % | — |
| Wall Cladding | 20 | 0 | 0.0 % | — |
| Perimeter Furniture | 35 | 2 | 5.7 % | Minor civil works adjustments |
| Doors / Hardware / Glass | 8 | 1 | 12.5 % | Damage during unloading |
| Gondolas / Central Furniture | 70 | 18 | 25.7 % | Poor packing of imported batch |
| **Total** | **146** | **21** | **14.38 %** | 85.7 % of incidences concentrated in one imported batch |

The global Site Incidence Index was 14.38 % (21 of 146 modules). Five of the seven furniture families registered 0 % incidences, demonstrating high effectiveness of the local design and manufacturing process. Of the 21 incidences recorded, 18 (85.7 %) corresponded to scratches on an imported batch of gondolas caused by inadequate packing and stowage during transport, not by design or local manufacturing errors. The indicator enabled precise root-cause isolation and documentation in the lessons-learned log for future improvement of logistics protocols.

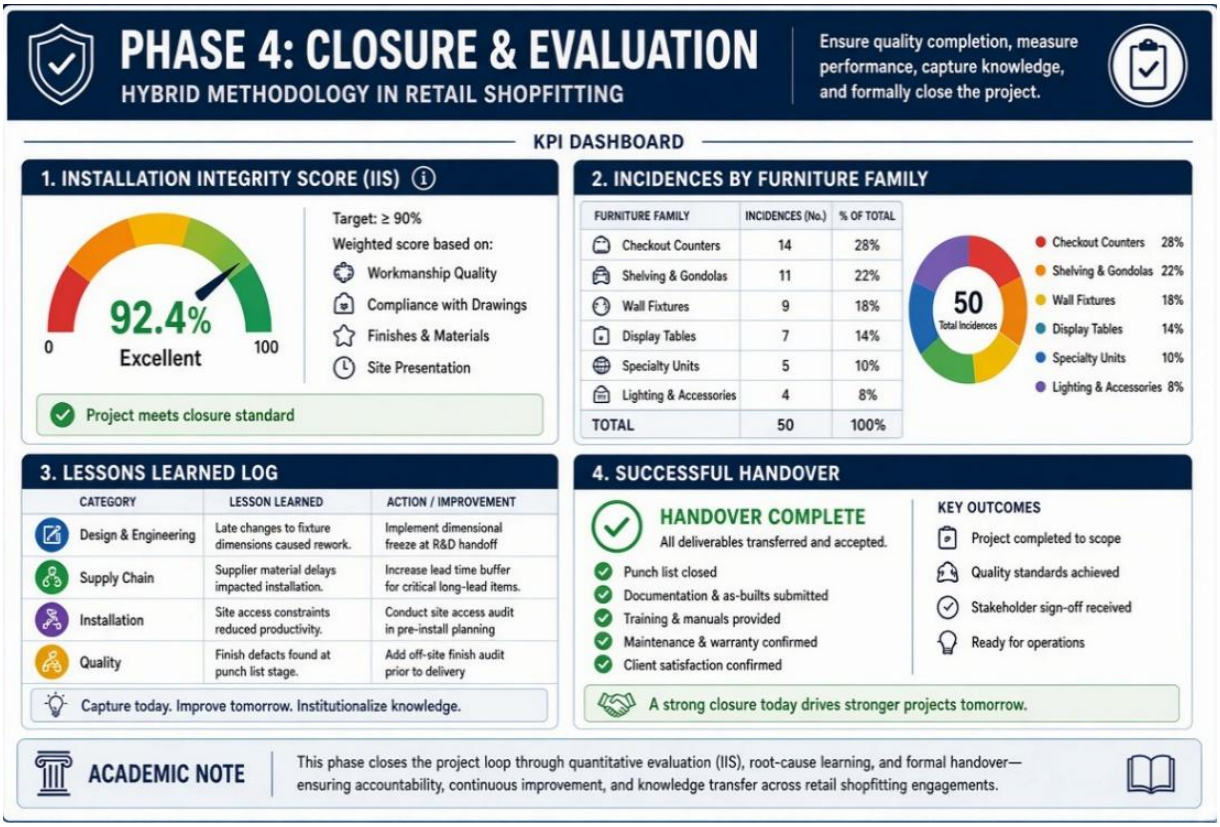



**Figure 5.** Closure & Evaluation

The final phase quantifies physical non-conformities during installation using the Site Incidence Index (IIS), classifies root causes by furniture family, and documents lessons learned. This closes the continuous improvement cycle and generates organizational memory for future projects.

## CONCLUSION

The present study demonstrates that a hybrid methodology integrating Concurrent Engineering principles with Lean Construction tools is both practical and effective for improving the management of retail shopfitting and fixture projects. By replacing traditional sequential and experience-based practices with structured stage-gates, pull planning, technical checklists, change control, and performance indicators, the Technical Office can significantly enhance the traceability of client requirements and reduce the propagation of errors from design to site installation.

The pilot implementation at the Oysho Ánima Los Cabos store confirmed that these tools can be deployed in a real industrial environment without requiring costly enterprise resource planning systems, relying instead on visual management, standardized templates, and disciplined collaborative routines.

The results obtained across the four phases provide quantitative evidence of the methodology's value. In the planning phase, the achievement of a 71.43 % Percentage of Plan Complete (PPC) illustrated the capacity of reverse planning and stage-gates to make external variability visible and manageable, protecting the non-negotiable commercial opening date despite delays originating from the client and the civil contractor. During detailed engineering, an 81 % Technical Deliverables Quality Index (ICET) showed that mandatory checklists and version control successfully filtered documentation errors before release to manufacturing, addressing one of the historical root causes that accounted for 28 % of operational impact. In the execution phase, the +9.38 % deviation in person-days was clearly isolated as the result of civil works delays and resource reallocation rather than internal planning failures, while still delivering the sales floor on time for visual merchandising.

Finally, the 14.38 % Site Incidence Index (IIS) revealed that five of the seven furniture families were installed with zero non-conformities, and that 85.7 % of recorded incidences were concentrated in an imported batch due to inadequate packing rather than local design or manufacturing deficiencies. This level of diagnostic precision transforms anecdotal knowledge into organizational learning.

Beyond the specific metrics, the research confirms that the combination of Concurrent Engineering and Lean Construction addresses the systemic problem of information fragmentation that characterizes multi-brand retail fixture operations. Stage-gates function as informational poka-yokes that prevent incomplete packages from advancing, while pull planning aligns fabrication and logistics with actual site readiness, reducing unnecessary handling and storage risks.

The formalization of a lessons-learned log and the systematic measurement of key performance indicators create a continuous improvement cycle that reduces dependence on individual experience and supports knowledge transfer among project managers. These outcomes are particularly relevant for companies operating in the Mexican and Latin American retail sector, where high client variability, compressed schedules, and limited digital infrastructure are common constraints.

The study also recognizes important limitations that bound the generalizability of the findings. The validation was conducted on a single pilot project (n = 1), so the results demonstrate operational feasibility rather than statistical causality or universal applicability. External variables such as client approval cycles, civil contractor performance, and international logistics remain outside the full control of the Technical Office, as evidenced by the deviations observed. Additionally, the historical baseline of warranty claims (45 % of projects) is not directly comparable to the modular IIS measured in the pilot, limiting the strength of before-and-after claims. These limitations, however, do not diminish the practical contribution; they clarify the conditions under which the methodology delivers value and the need for longitudinal monitoring across multiple stores.

In conclusion, the hybrid methodology offers a replicable, low-cost framework for retail fixture companies seeking to professionalize their technical offices. It improves documentary quality, stabilizes planning reliability, protects commercial opening dates, and generates actionable data for continuous improvement. Future work should focus on multi-project replication, the integration of the tools into product data management or product lifecycle management systems, and the measurement of long-term effects on warranty rates and overall project profitability. By institutionalizing these practices, organizations can move from reactive problem-solving to proactive, data-driven management of client requirements in the demanding environment of global retail shopfitting.

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