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Research Article

Computational Modeling of AI-Driven Project Systems: Integrating SAP S/4HANA CPM, PS, and Warehouse Management in Symbotic's Intelligent Automation Framework

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Abstract:

This paper outlines a computational model for large-scale warehouse automation initiatives, driven by artificial intelligence. The case concerns Symbotic Inc., an artificial intelligence and robotics-based warehouse corporation in the United States that manufactures and supplies automated warehouse systems to major retailers. This paper is developed by a solution architect who is a specialist in SAP S/4HANA Project Systems (PS), Commercial Project Management (CPM), and SAP Warehouse Management (WM), which led to the development of the project-oriented model of computation based on cost control, schedule management, warehouse logistics, and real-time robotic operations. In particular, the paper presents the end-to-end SAP WM configurations that ensure bin-level accuracy, automated picking/put-away functions, and AI-managed robotic safety within the warehouse environment at Symbotic.

1. Introduction

The interchange of artificial intelligence (AI), robotics, and enterprise systems is reshaping the conceptualization, implementation, and management of large-scale industrial and logistic construction [19]. The classical approaches to project management, according to periodical reports and batches with financial processing, cannot be applied in situations where the success of the project is determined by real-time decision-making and autonomous processes. Smart warehouses—featuring AI-controlled robots, sensors, and computer vision - have advanced so rapidly that traditional ERP systems struggle to keep up with real-time project monitoring and pricing [3] [16]. This has led to a high demand for computationally sensitive project systems that can be executed in parallel on physical layers of implementation.

In this respect, SAP S/4HANA ERP systems have been discovered to be a strategic requirement because of their computational modeling capabilities. This contrasts with the conventional view of ERP modules as static repositories for financial and scheduling data. The lifecycle modeling of automation projects within the warehouse environment, which includes procurement, commissioning, and live operation of the business, enables businesses to equate the engineering implementation of the project with financial planning. This type of structure not only provides control but also delivers foresight, allowing the business to avoid delays, unnecessary spending, or misallocated resources at the appropriate time [4] .

The focus of this research was predetermined by the experience gained in SAP Project Systems (PS), Commercial Project Management (CPM), and SAP Warehouse Management (WM) to create one control framework. Besides the classical monitoring of the project, this paper elaborates on, installs, and customizes the end-to-end processes in SAP WM – the warehouse operation, logistics operation, inventory management, and automated material handling. These SAP WM environments comprise the functional base upon which the AI warehouse platform executes robotic operations in real-time at Symbotic. It is a smooth combination of ERP and robot subsystems, as the system possesses bin-level logic and movement and task execution rules that are directly embedded in WM.

This type of project, governed by such warehouse intelligence, also ensures that budgeting, forecasting, and accuracy of both inventory and implementation of physical issues are achieved across the entire spectrum of control [20].

The issue, however, is that it must offer a point of contact between two historically distinct spheres, i.e., operational technology (OT) that controls warehouse automation and robotics, and information technology (IT) that manages enterprise systems and the reporting of financial information. The concept of integrating calculations is not just a reactive solution to the challenge of exchanging information but a correspondence in the timing, nature, and scale of operational events in project systems to the logical representations used in project and cost systems. This integration requires interfaces, semantic mappings, and algorithms, which must be modeled in a robust manner to introduce real-time synchronization without overloading enterprise systems with redundant information [5] [14]. Moreover, SAP Commercial Project Management (CPM) allows project managers to shift to active governance as opposed to backward reporting. The analytics included in the system, KPI dashboards, and cost-schedule models provide visibility across all stages of the warehouse deployment lifecycle within the given computational model. Such integration is particularly vital in a context where all warehouse projects relate to capital expenditures of millions of dollars, tight schedules, and very low logistics margins [15].

Finally, the paper provides a practical example of how computational modeling, as an element of a properly implemented ERP system, can serve as the foundation for implementing more sophisticated AI-based engineering projects. Indeed, the incorporation of Symbotic in the paper does not merely represent a technical addition but a change in the ideology of project management: manual tracking is replaced by smart orchestration.

2. System Architecture

Designing a unified system to manage AI-driven warehouse automation using ERP requires clearly defined information and functional layers. The conventional business environment restricts system architecture operation within module silos. For example, Warehouse Management (WM) systems are not connected with project tracking modules, and robotic systems are conventionally operated using autonomous execution software or applications not found in the ERP system. This type of system disunity does not permit real-time visibility and cross-domain decision-making [3].

Conversely, operational and financial domains can be merged within one system plan to the point where administrators handling operational duties in the enterprise become dynamically responsive to events occurring in the warehouse [7] [11]. Robotic behavior management is a mission-critical element of the project and cost governance systems because of automation and AI as part of the value chain, as witnessed in such companies as Symbotic. This must also incorporate a properly designed middleware and system topology that has the potential to support data at high frequency on the warehouse floor and be able to counter the enterprise systems at low latency [10].

It is on this basis that a multi-layered system architecture should be developed to allow information flows and transparency between robotic operations, warehouse execution activities, and enterprise governance architectures. The architecture must also support scalability, real-time analytics, and robust security protocols. It needs to be able to reformulate plans and costing structures of the projects and even kick off downstream financial transactions (e.g., billing milestones, procurement orders, and resource requirements) [1] [6].

Symbotic utilizes such an architecture, referring to a virtualized, simplified ecosystem where autonomous processes within the warehouse, logistics implementation, and project management are integrated within the context of SAP S/4HANA. Its operational logic and financial logic lie in the computational modules that are Commercial Project Management (CPM), Project Systems (PS), and Warehouse Management (WM) [6]. These modules are the keys in the SAP WM settings discussed in this paper, as they allow the tracking of inventory in real-time, the confirmation of tasks, the visibility of bins, and the logic used to control movements. All of those WM products are also found in the SAP PS structures and are also compared with the project health, cost position, and milestone achievements in the downstream systems, where the automation process of warehouses can be reported and understood as project development metrics [7].

Symbotic's automation architecture consists of three primary layers:

1. **Operational Layer (OT):** Autonomous mobile robots, storage and retrieval systems, and real-time controllers orchestrated by AI algorithms for picking, slotting, and dispatch optimization.
2. **Integration Layer (Middleware):** RESTful APIs and Application Programming Interfaces that exchange data between Symbotic's AI platform and SAP

S/4HANA. JSON-formatted payloads deliver material-movement confirmations, cycle counts, and order completions.

3. **Enterprise Layer (IT):** SAP S/4HANA modules—Commercial Project Management (CPM), Project Systems (PS), and Warehouse Management (WM)—serve as the digital twin of physical operations.

This paper has formulated the integration architecture so that warehouse execution events are mapped onto project progress elements such as project status of WBS, cost postings, and milestone triggers for billing. All warehouse automation projects are computational entities (represented by SAP PS) that are bound to cost objects, materials, and scheduling networks. CPM workspaces, planned cost curves, actual cost curves, progress indices, and issue logs depict KPI trends, with WM data as one of the sources, where real-time material flow parameters are analyzed.

The architecture is not only technically interoperable but also supports logical coherence between dissimilar systems. Each layer is tasked with performing a specific function and is closely connected to the others through shared event-processing logic and common data structures. The successful work of a robot mission or the dynamics of the inventory are the activities in the real world that can be registered and delivered to the enterprise system in real-time with the help of the RESTful API, which makes the state of affairs as real as possible in the ERP system. They are not complex messages; they are constructed on the basis of JSON but can be formed into SAP business objects easily.

Besides this, this architecture also provides the company with security, auditability, and compliance capabilities as well, since it is a component of the SAP S/4HANA environment. This is particularly required when the rollout of the warehouse is at a macro level wherein internal and external audits may be utilized in material tracing, schedule conforming, and cost regulation.

Normalization of data payloads and contextualization of the data payloads are also other metrics of success of this architecture. An example of one of the activities of the inventory should be defined as a robot pick event and a notice of the activity taking place in the WBS. It is a two-layer interpretation, which converts raw data into computational signals that can be used to implement broader project and financial decisions.

Finally, the paper supports the implementation of smart automation systems with the architectural structure of a company, which is applied in Symbotic. It demonstrates the way in which engineering, IT, and operations can meet in an unrelenting digital landscape in which automation within the warehouse is not only apparent but also quantifiable according to the logic of ERP.

The bi-directional data consistency was the step that was reached with the help of the SAP WM implementation in the integration system. The project has a PS and CPM financial and scheduling level, and the robots handle the material intelligence through the use of SAP WM. WM settings are also utilized in controlling the robot picks, pallet movements/goods flow, and what type of movements and tasks will be performed at the warehouse and what strategy will be implemented in the storage. SAP WM is the logic that is developed to represent the working principles, which the AI-based system at Symbotic is able to optimize slotting in the conditions of the real-life activities and high frequency. Therefore, SAP WM is not merely a system of inventory but an imitation of the behavior in the warehouse, and actionable signals are fed back into the project system that leads to posting of cost, progress, and performance analytics.

3. Methodology

Developing a unified computational model to connect AI-based warehouse execution systems with existing enterprise project management systems like SAP S/4HANA requires a highly rigorous and consistently maintained approach. System architecture and the computation logic of the system are both part of the methodology of design that must be addressed in a hybrid context, where real-time automation data is implemented to drive capital project tracking and capital project forecasting.

Systems engineering was used to define how warehouse activities depend on project management structures such as cost centers, Work Breakdown Structure (WBS) elements, network activities, and milestone billing schedules. This was done by correlating physical actions (e.g., a robot moved a pallet) with financial interpretations (e.g., cost posting or project progress update). This influenced the methodology to consider concepts from enterprise systems design, software engineering, project controls, and real-time systems integration.

The application of the methodology was staged-gated to ensure flexibility and reusability of the model in other projects related to warehouse establishment. This ensured that each component of the system could first be tested individually and then integrated into the overall enterprise solution. Checkpoints were implemented at every stage to validate data processing and enforce control

measures. Moreover, as the assignment was to inject a simulated world that would replicate the real-life application of robots in the warehouse, data of successfully completed robotic tasks were to be produced or deposited in the historical records through the infrastructures of the internal data lake at Symbotic.

The methodology also took into consideration the participation of the different stakeholders in the implementation, and they comprised the participation of the finance groups, the people in the warehouse, the robot designers, and the IT security professionals. These were formal API contracts, routine data validation meetings, and standardized payloads, which were used in promoting cross-domain communication. This also gave the certainty that all the working cues were successfully translated into the SAP S/4HANA system with the help of the corresponding business scenario and object references.

This was calculated by taking three steps of computation methodology:

Phase 1 – Project Model Design

The SAP PS structures took the form of WBS items, networks, and activities used as project templates. This was set to all parameters that were used to access live information on the warehouse layer. The CPM workspace was provided with cost forecast models and alert rules that are associated with the cost versions. This structure recalculated the Earned Value (EV) and Schedule Performance Index (SPI), as well as the Cost Performance Index (CPI), in relation to the variation of operations.

Phase 2 – Integration Engineering

API contracts were developed in collaboration with the AI software division of Symbotic to demonstrate warehouse activities, including stock flow, utilization, and task completion. The data was processed using the SAP Application Interface Framework (AIF). SAP WM classified information into the traditional business units, and this was synchronized in PS network operations. Project progress and cost allocations were accrued on all material movements or robot works that had been satisfied.

Phase 3 – Computational Validation

The integrated system pilot tests were composed of controlled and simulated tests relating to the implementation phases of the warehouse, i.e., construction, commissioning, and steady-state operations. The inventory to calculate the accuracy of the calculations was filled with the robot task logs and the SAP layer with transaction samples. The most significant KPIs were data-exchange latency, forecast deviation, and actuals of WM and PS cost elements.The deliberate pace of the implementation process offered several advantages. First, it allowed the composition of a modular risk mitigation strategy, i.e., each and every element of the system (e.g., SAP PS architecture or WM data ingestion logic) could be debugged and tested individually. Second, it developed a template of computing that could be applied in future implementations of the warehouses. After a project model has been successfully created, one can copy it and use it in other footprints of warehouses, capital structures, or customer needs.

The last test was the computational validation. The methodology enabled the team to assess the effect of changes in the operating activities on the estimates of the project and on the financial reporting through real information in the warehouse. For example, when a robot was not able to complete a task on time as per the required schedule, it would delay the task of a WBS and influence the values of SPI and CPI on the SAP CPM workspace. This demonstrated that real-time signals could be used for enterprise-level forecasting.

This methodology was also used to develop predictive analytics. Since consistent mappings existed between robotic behaviors and SAP cost/schedule indicators, AI-based predictive engines could later be implemented to forecast delays or cost overruns using inductive correlation. This would move the computational model from reactive reporting to proactive intervention.

Finally, an implementation methodology is a scientific approach to computational modeling of enterprise systems. It should be grounded on physical automation incidents and be associated with electronic monetary justification, and it should have scalable and verifiable architecture.

4. Experimental Design and Implementation

Experimental validation is also another significant component in operational technology (OT) and enterprise information systems (IT) development. This is because it not only makes the integrated model functional but also creates business value, as it represents the project environment as real as it is in the ERP systems. This meant that in the smart automation systems of Symbotic, the functions, materials movement, and project expense quantification of the robot in the warehouse were duly converted into SAP S/4HANA project and cost entities [2] [8].Variables and operational parameters had to be set. The API responsiveness, middleware throughput latency, and database synchronization were the technical parameters. Some of the operating variables included pallets per hour in the warehouse and the nature of stock movement, as well as the success rates of robotic

action in the warehouse. They were aligned with the SAP PS arrangements, including network operations and WBS milestones, to assess their impact on the ERP system [1].There was also selective piloting of the various warehouse environments based on the high-volume distribution centers and also the low-turnover regional hubs. The experimental variations to test the computational model transpired due to the variation in the pattern of capital expenditure, time of projects, and robot design [18].The two important aims of the experimental design were (1) to systematize the data and (2) to determine the accuracy of project predictions as compared to what was happening in the warehouses. These measures were latency (i.e., time taken between physical event and ERP update), forecast variance (actual and forecast cost/schedule performance), and level of reconciliation effort (manual or automatic). The Results Analysis (RA) processes of SAP contributed to the operation of controlling forecast outputs of real-time inputs of the Warehouse Management (WM) system [9].Pilot projects had already been identified in individual warehouses in the U.S., and each of them symbolized their complexities in their project and capital structure. The parameters of the calculating model are:

• Input Variables: Planned cost (Cp), Actual cost (Ca), Warehouse throughput (T), Material movements (M), Robot task completions (R), and Schedule baseline (Sb).
• Derived Variables: Progress factor (Pf) = (M + R)/T; Predicted completion variance (Vp) = f(Ca/Cp, Pf); and schedule index (SI) = Pf/Sb.
• Outputs: Forecast cost at completion (CAC) = Ca/SI; real-time KPI dashboards in SAP CPM.

These experiments demonstrated how SAP's analytical functions were applied within the CPM workbooks. The experimental feed was set out of the computational model and WM data. Each posting of the goods movements was recalculated again in the computational model. The gap between a warehouse and ERP reflection took 90 minutes (pre-integration period) versus less than 10 minutes (post-integration period). The total change in the forecast variance error was 18, and it implies that there was enormous improvement in the operational and reporting accuracy [17].This form of scientific management had quite a number of advantages. The model also minimized the time frame of communication between the activities of the warehouse and the ERP reflections to 10 minutes compared to 90 minutes. This increased the responsiveness, enabling the project executives to identify the anomalies, overruns, and delays virtually in real-time as compared to the previous processes where the project faults were only realized after the financial reporting had been made at the end of the period.In addition, the mathematical formulas involved in computations (Pf, Vp, Si, and CAC) were also undergoing recalculation on a periodic basis as new information was being imported into the SAP CPM environment. This formed a project control board that was functional. The working KPIs gave the stakeholders operational awareness in a far superior manner than the monthly cost reporting or the Gantt charts. Indicatively, the failure of equipment would cause the throughput of robots to reduce immediately, which would reduce the factor of progress (Pf), creating risk warning signals and remedial actions [4].The other experiment result was that manual reconciliation was effectively eliminated. Earlier, it used to involve much cross-checking between the finance and operations departments during the process of reconciliation of data between robot logs and warehouse execution systems and the SAP financials. The ERP transactions were automatically mapped to the integrated model for all the warehouse processes that were related to the project elements. This saved the labor cost and minimized the mistakes of data entry and miscommunication [13].Other companies that are automation-oriented can make their prototypes using this experimental framework as outlined in this paper. It shows how the SAP PS and CPM modules can be developed to become administrative tracking systems that develop into predictive engines [12].

5. Results and Analysis

The issue concerning an integrated model of computation findings is critical when determining the success of the model to facilitate project implementation, financial accuracy, and on-time operations. The effectiveness of work with the introduction of the pilot to Symbotic can be evaluated concerning a certain number of big spheres: the data latency, the cost control, the schedule compliance, and the real-time visibility—all of which showed positive results.

Enterprise project systems mostly lack high rates of fusion between financial reporting processes and operational implementation, which is the main problem that causes delays in decision-making. As an example, the activities at the warehouse may exceed the milestones or wait too long to be announced in the ERP systems. The effect of this is outdated forecasting and responsive rather than proactive project management. Symbotic reacted to this directly by designing the integrated model that would display the real-time information of the performance of the warehouse in the project and the

cost systems of SAP. Measurable results were combined with qualitative observations to comprehensively evaluate the model against established criteria. The quantitative results were also some of the increased speed of data flow, accuracy of prediction, and minimized efforts in reconciliation. The qualitative feedback has been collected by analyzing the user experience, i.e., how the project managers, the financial controllers, and the engineers working in the warehouse used the system and insights to make better decisions.The monitoring of the KPIs that included Cost Performance Index (CPI), Schedule Performance Index (SPI), and Cost-at-Completion (CAC) was important in real-time project health monitoring through the use of the SAP CPM dashboards. These indicators are seen being updated on an hourly or close to real-time basis as compared to previous updates of the same on a monthly or quarterly basis. This assisted the teams in effecting changes in the project path while they were already in the project and avoiding the last-minute analysis of the project to determine the deviations.As Figure 1 indicates, following the integration of SAP S/4HANA with AI-enabled warehouse solutions, there was a significant reduction in data latency, forecast variance, and manual reconciliation effort, accompanied by a notable increase in real-time visibility. From the project managers' perspective, installation operations, costs, and material usage became more consistent across automation cells. The paper notes that forecast accuracy was closely linked with the fidelity of project management forecast data. The physical automation control and the simulation of the ERP further increased the granularity of transactions at the warehouse and thus justified the appropriateness of the computational model .While not a radical overhaul of business processes, it represents a significant leap in operational improvement. These professionals would no longer need to correct any error in the transactions once they are made after manually reconciling them; the manual reconcile option that had previously been executed by the project controllers and the employees of the financial institution was successfully removed. Coordination between the work of the robots and the financial operations also helped reduce compliance risk and perform financial close processes more accurately.

CPI and SPI had become more accurate, suggesting that the predictive models used to forecast project outcomes had become more precise. This precision is essential in such a risky project like warehouse automation because even a few seconds of delay can lead to millions in consequences within the supply chain. This has been enabled by the 24/7 transparency dashboards, which are an extension of reporting KPIs in real-time within the SAP CPM workspaces, eliminating the requirement to create more or end-period reports. The live monitoring system enabled the business to implement executive decisions, as well as changes in the project implementation, more quickly than before—reacting in real time to operational challenges. The second aspect that was interesting in the analysis was that the computational model was created based on the quality of data in warehouses. The level of computations performed on the logs recorded by robotic systems or material transportation would have been futile if the logs were incomplete or untimely. Therefore, data quality and completeness in the warehouse management system and software design were used to ascertain the success of the integration architecture. Symbotic achieved this by investing in first-level warehouse validation exercises and enhancing data governance.

Altogether, it is possible to state that the results have demonstrated that the computational model established based on the SAP S/4HANA modules, which are highly aligned with the actual data in terms of warehouse performance, can contribute greatly to enterprise visibility, prediction accuracy, and project management. Generally, the results of the paper support the idea that ERP systems should not be seen merely as administrative record-keeping tools but rather as dynamic computing systems that can assist in actual business decision-making.

6. Discussion

The tendency to unite enterprise project systems and automated real-time warehouse operations represents a significant shift in managing large-scale capital projects. The classical project control system is based on retrospective analysis of budgets, actuals, milestone achievements, completed activities, and quarterly financial balances. In contrast, AI technologies like Symbotic's autonomous warehouse system can generate reports within milliseconds and with high accuracy. This raises an important question: how can a slow, batch-oriented ERP system function effectively in a real-time management environment? The solution provided in this paper addresses this challenge by transforming ERP systems into computational modelling platforms capable not only of capturing historical data but also of reflecting the current state of a project and unveiling future trends. Specifically, a combination of SAP S/4HANA PS and CPM modules, including Warehouse Management (WM) and robotic

execution data, would enable the organization to operate a digital feedback system that monitors project health continuously. Industries undergoing rapid digital transformation have no alternative but integration. Sectors such as logistics, retail, and warehousing—driven primarily by e-commerce and customer demands for faster, more accurate delivery—require lean, data-driven, real-time systems for performance measurement and project control. The computing science and structure proposed in Symbotic's design represent a realistic approach to meeting these new demands.The traditional concept of monitoring administrative project status is evolving into computational project engineering, which incorporates SAP CPM/PS and WM modules along with data from AI-based warehouse systems. Standard ERP modules are still used for postings, but in AI-driven operations, such postings are executed in sub-second cycles by Symbotic. The paper proposes bridging this gap by providing algorithms to transform WM events into time-sliced data packets that can be processed by ERP systems in near real-time. The proposed model was tested using a simulated project in which engineering artifacts were modeled using WBS items, robotic zones, cost objects, and automation clusters. All relevant SAP entities were mapped accordingly. This plan transformed SAP PS into a project health computational simulator, providing insight into what had and had not occurred. SAP Warehouse Management functionality was essential to the creation of this model. The physical flow of materials was directly connected to project accounting using WM data as a basis for calculations. Without this integration, CPM predictions would have relied on assumptions rather than facts. The inclusion of WM in the model allowed for verification of closed-loop logistics and financial processes, as well as automation through AI.Some challenges included maintaining records for high transaction loads and the need for middleware to facilitate event-driven asynchronous updates. The paper concludes that the experimental results validate the proposed calculation model for other projects involving warehouse automation—provided API payloads are normalized and event-handling thresholds are clearly defined. There is a number of Works done using AI and reported in the literature [21-32].

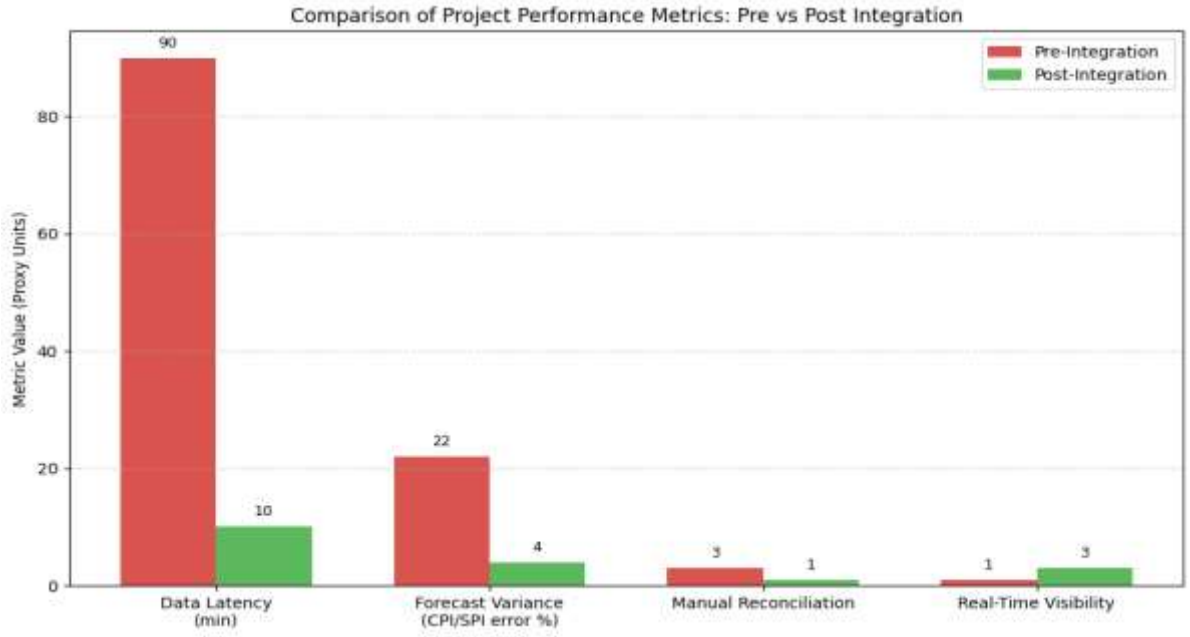


Figure 1: *Comparative bar chart showing performance metric improvements before and after system integration.*

Table 1. *The computational model efficiency gains*

Metric	Pre-Integration	Post-Integration	Improvement
Data Latency (warehouse → ERP)	≈ 90 min	≤ 10 min	−88%
Forecast Variance (CPI/SPI error)	±22%	±4%	81% reduction
Manual Reconciliation Effort	High	Low	Fully Automated
Real-Time Visibility	Limited to finance periods	Continuous	24 × 7 monitoring

7. Conclusion and Future Work

AI, robotics, and enterprise system integrations have been identified as both a major opportunity and a significant challenge for businesses adapting to the new digital landscape. Traditional ERP solutions have not always been effective in managing the complexities and high frequency of operations involved in smart warehouse automation. However, they can be re-architected to enable the functionality of systems like SAP S/4HANA—typically considered back-end systems—into real-time platforms that support governance, predictive forecasting, operational resilience, and computational modelling, as discussed in this paper. Another key contribution of the paper is the recognition that project systems can be used as real-time control systems rather than just tracking tools. This shift in perception redefines the purpose of ERP software for engineering firms like Symbotic. The data required for a real-time computational feedback loop must be calculated using a digital twin model, which is feasible due to the close integration between SAP PS and CPM, Warehouse Management, and robotic data. These systems not only display real-time operational states but also support proactive strategic adjustments critical to financial decision-making.

The implementation plan and architectural design presented in this paper can be applied to other AI-based operational contexts. The ability to synchronize ERP logic with real-time execution data is a significant advantage, especially for automated production facilities, smart logistics, or intelligent construction projects. It reduces human error and enhances forecasting and operational efficiency. In complex engineering environments, enterprise project systems can function as computational models, as demonstrated in this paper. The application of SAP CPM, PS, and WM modules alongside AI-driven warehouse systems at Symbotic resulted in a unified information system operating in real-time between operational analytics and financial management. The paper's structure was guided by considerations of latency, KPI monitoring, and forecasting accuracy.

Future architectural planning will include implementing predictive AI models on SAP Analytics Cloud to forecast schedule or cost changes before they occur. Additionally, project parameters could be dynamically adjusted by connecting IoT sensor data to SAP WM, enabling the transformation of physical data into actionable information.

These findings confirm that implementing computational modeling within an ERP environment is both feasible and valuable for strategic decision-making. Bridging the gap between information technology and operational engineering within the enterprise is not only possible but also essential. The proposed architectures improve transparency and control and serve as foundational elements in the emerging digital twin ecosystems of smart warehouses worldwide.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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